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ELECTRICAL SAFETY AT INDUSTRIAL PLANTS. (CHAPTER 8 AND 24),(U)
JAN 78 V I KOROL'KOVA

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ELECTRICAL SAFETY AT INDUSTRIAL PLANTS
(CHAPTER 8 and 24)

by

V. I. Korol'kova

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ELECTRICAL SAFETY AT INDUSTRIAL PLANTS
(CHAPTER 8 and 24)

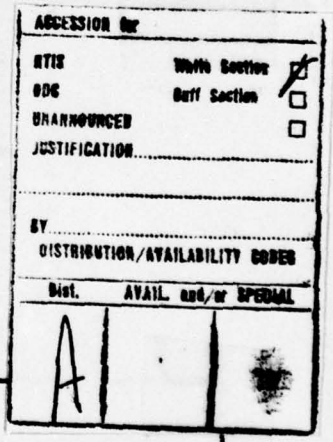
By: V. I. Korol'kova

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FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

Table of Contents

U. S. Board on Geographic Names Transliteration System and Russian and English Trigonometric Functions..... ii

Chapter 8. Requirements for Safety, Presented to Equipment of Electrical Networks, Installations, Equipment..... 1

Chapter 24. Thunderstorm Protection of Buildings and Installations..... 173

References..... 266

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

Chapter 8.

Requirements for safety, presented to equipment/[redacted] of electrical networks, installations, equipment.

1. Electrical lines.

Besides the general requirements for electrical safety about which was said above, the relating to all forms electrical equipment/devices, there are special requirements with respect to electrical safety, which reflect the specificity of the individual forms of electrical equipment/devices and their operation.

Any forms of electrical equipment/devices (grid/network, setting up, equipment) using their design concept and mounting method must answer their designation/purpose; correspond to the voltage/stress under which they must be operated; to the operating mode; to the conditions of surrounding medium and, finally, the qualifications of their service personnel in accordance with the operating rules of

equipment/device, technical operation and safety of maintenance.

Page 73.

By construction distinguish electrical lines air and cable.

Aerial lines.

Electrical safety of aerial lines is provided by the suspension of wires earth referenced, sex/floors, service platforms, roofs, balconies and so forth on vertical line and relatively near the arranged/located buildings, installations, railroads, autoroutes etc. on horizontal on the distances, which eliminate the possibility of dangerous approach/approximation or touch to wires. Table 9 shows the smallest permissible vertical distances with the greatest sagging of the wires of aerial lines, which intersect the different territories into objects (in meters).

Table 9.

(1) Объекты пересечения	(2) Напряжение в кв				
	1	2—20	35—110	150	220
(3) Населенная местность и территории промышленных предприятий (фиг. 20, *а*)	6	7	7	7,5	8
(4) Ненаселенная местность (см. фиг. 20, *б*)	5	6	6	6,5	7
(5) Воздушные линии напряжением до 1000 *в* (см. фиг. 20, *в*)	(6) От 2 до 7 *м** (7)				
(8) Линии связи и сигнализации (фиг. 21)	1,25	2—4** 3—4***	3—5	4—6	4—6
(9) Железные дороги общего пользования, электрифицированные железные дороги, автомобильные (фиг. 22)	7,5 6	7,5 7,0	7,5 7,0	8 7,5	8,5 8
(10) Водо-, газо-, теплопроводы, канализационные трубы	1	3	4	4,5	5 *м*
(11) Пожарные гидранты, колодцы, водоразборные колонки	2	—	—	—	—
(12) Бензиновые колонки	5	—	—	—	

Key: (1). Objects of intersection. (2). Voltage/stress in kV. (3). Populated locality and the territories of industrial enterprises (Fig. 20a). (4). The unpopulated locality (see Fig. 20b). (5). Aerial lines by voltage/stress to 1000 V (see Fig. 20c). (6). From. (7). to. (8). Lines of communication/connection and signaling (Fig. 21). (9). The railroads of the common/general/total use, electrified are the railroads, automobile (Fig. 22). (10). Water, gas-, heating mains, sewers. (11). The fire hydrants, pits, water posts. (12). The gasoline pumps.

FOOTNOTE [1]. Depending on voltage and span length in m. ENDFOOTNOTE.

FOOTNOTE [2]. For voltage 10 kV. ENDFOOTNOTE.

FOOTNOTE [3]. For voltage 20 kV. The first numeral indicates distance when, aerial line, lightning-protection line is present,; the second numeral - in the absence of lightning-protection line. ENDFOOTNOTE.

Page 74.

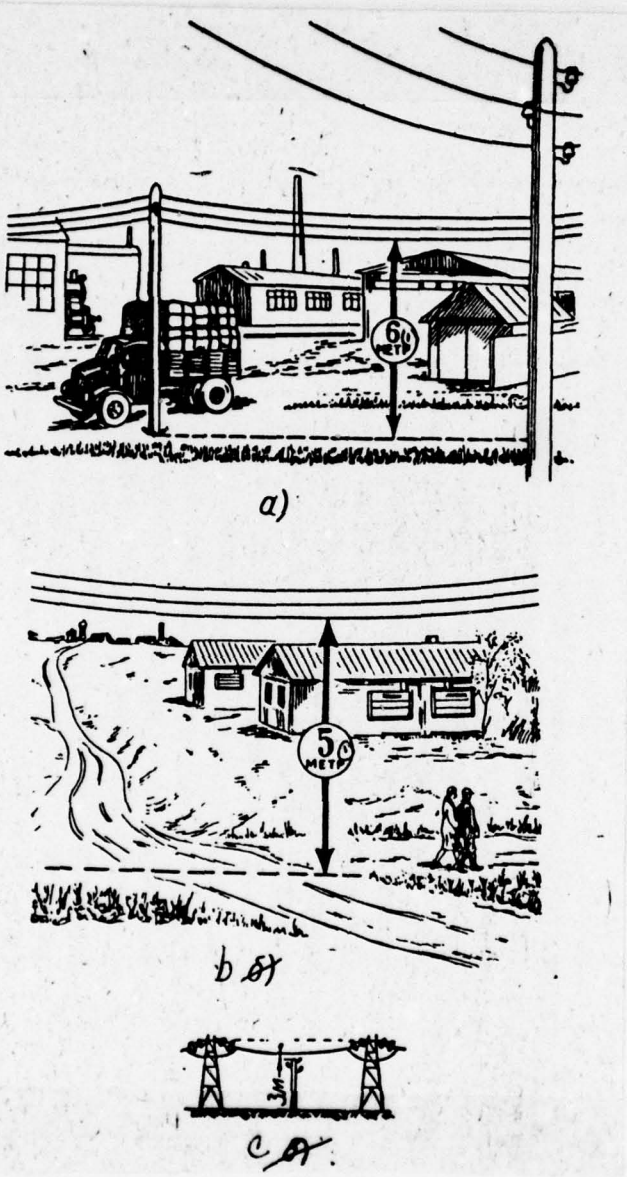


Fig. 20. Dimensions of suspension of wires by voltage/stress up to

1000 V. a - during intersection of populated locality, b - during intersection of unpopulated locality, c - aerial lines by voltage/stress to 1000 V.

Key: (1). Meter.

Page 75.

Vertical distance (in m) from the wires of input/introductions to the earth/ground, the place of the motion of transport, railroad lines, buildings they must be not less indicated in Table 10.

The smallest permissible distances on horizontal (in m) from wires to different objects are shown in Table 11.

For the purpose of the prevention/warning of the break of wires and connected with this possibility of heavy electrotraumas (with lethal outcome) the operating rules establish/installed the following smallest permissible sections of wires depending on their material and the voltage/stress of setting up.

Table 12 shows the smallest sections of wires, permissible according to the conditions of mechanical strength.

By the operating rules is allow/assumed the combined suspension of wires on common/general/total supports with the observance of the following requirements, presented in Table 13.

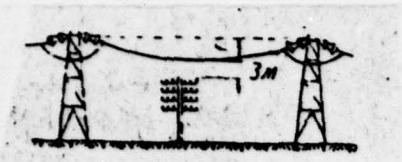


Fig. 21.

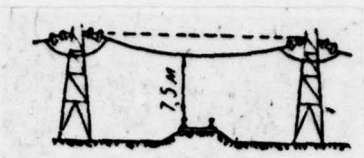


Fig. 22.

Fig. 21. Dimensions of suspension of wires during intersection of lines of communication/connection and signaling.

Fig. 22. Dimensions of suspension of wires about intersection of railway line of common/general/total use.

Table 10.

(1) Габариты	(2) Напряжение в кв						
	(3) до 1	1—3	6—10	20—35	100	150	220
(4) От проводов вводов, пересекающих проезды и места движения транспорта (фиг. 23)	6	7	7	7			
(5) От проводов вводов до железнодорожного транспорта (фиг. 24, *а*)	7,5	7,5	7,5	7,5			
(6) От проводов вводов, не пересекающих проезды и места движения транспорта (см. фиг. 24, *б*)	3,5	4,5	4,5	4,75			
(7) От проводов вводов до крыши (фиг. 25) несгораемых производственных зданий и сооружений	2,5	3	3	3	4	4	5

Key: (1). Dimensions. (2). Voltage/stress in kV. (3). to. (4). From the wires of input/introductions, which intersect passages and the places of the motion of transport (Fig. 23). (5). From the wires of input/introductions to rail transport (Fig. 24a). (6). From the wires of the input/introductions, which do not intersect passages and the places of the motion of transport (see Fig. 24b). (7). From the wires of input/introductions to the roof (Fig. 25) of the incombustible production buildings and installations.

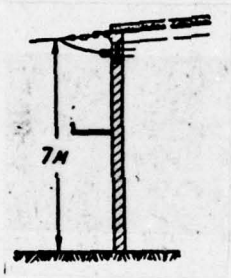


Fig. 23. Dimensions of suspension of wires of input/introductions, which intersect passages and places of motion of transport.

Page 76.

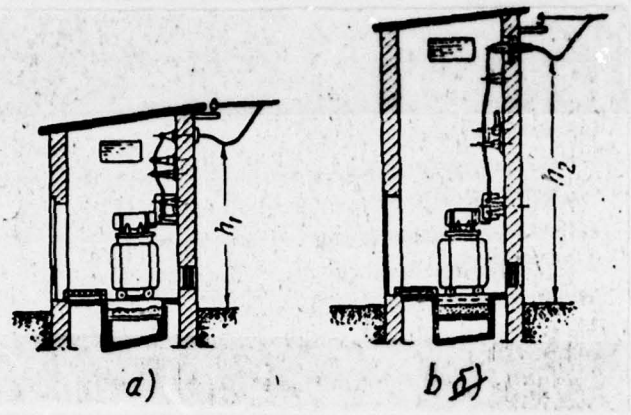


Fig. 24. Dimensions of suspension of wires of input/introductions, which do not intersect passages and places of motion of transport. a is the height/altitude h_1 = 3.5 m with voltage/stress of wires to 1 kV, b - height/altitude h_2 = 4.5 m with the voltage/stress of wires from 1 to 10 kV inclusively.

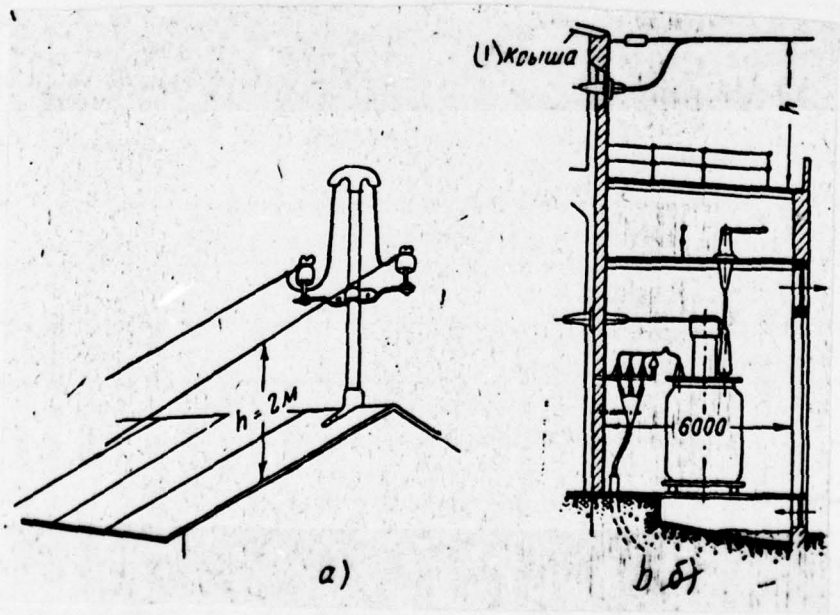


Fig. 25.

Fig. 25. Distances from wires of input/introductions on roof of surface of roof. a - the addition of wires into the building through iron pipe, b - distance h = 3 m with the voltage/stress of wires to 35 kV, h = 3.75 m with the voltage of wires 110 kV.

Key: (1). Roof.

Page. 77.

TABLE 11.

(1) Объекты сближения	(2) Напряжение в кв				
	до 1	до 20	35—110	150	220
(3) Строения (фиг. 26)					
(4) Балконы, террасы, окна	1,5	—	—	—	—
(5) Глухие стены	1,0	3	3	4	5
(6) Крыша*	—	2	4	5	6
(7) Воздушные линии связи и сигнализации					
(8) Нормально** (фиг. 27)	2	2,5	5	—	7
(9) В стесненных условиях***	1	2	4	5	6
(10) Железные дороги общего пользования	(11)				
От любой части опоры до ближайшего рельса (фиг. 28)	Высота опоры	—	—	—	—
(13) От опоры до габарита:					
(14) электрифицированной железной дороги	5	—	—	—	—
(15) неэлектрифицированной железной дороги	3	—	—	—	—
(16) Автомобильные дороги					
(17) От основания опоры до кювета или до полотна дороги	1,5****	25	25	25	25
(18) Трубопроводы	(11) Высота опоры	3	4—4,5	—	5

Key: (1). Objects of approach. (2). Voltage in kV. (3). Structures (Fig. 26). (4). Balconies, terraces, windows. (5). Dead/blind walls. (6). Roof

FOOTNOTE 1. The passage of aerial lines is allow/assumed above the incombustible production buildings and installations. ENDFOOTNOTE.

(7). Aerial lines of communication/connection and signaling. (8). Is normal 2 (Fig. 27).

FOOTNOTE 2. The separations of aerial lines and the lines of communication/connection and signalings are determined on the basis

of calculation on the coupling circuit and signaling, but they must be not less than the height/altitude of the highest support.
ENDFOOTNOTE.

(9). Under the squeezed conditions [3].

FOOTNOTE [3]. Distances are shown for the squeezed route. Is normal the distance between centers of aerial lines I, II and of III classes must be not less than the height/altitude of the highest support.
ENDFOOTNOTE.

(10). The railroads of common/general/total use. (11). Height/altitude of support. (12). From any part of the support to the nearest rail (Fig. 28). (13). From support to dimension. (14). the electrified railroad. (15). unelectrified railroad. (16). Highways. (17). From pole footing to container or to roadbed. (18). Conduit/manifolds.

FOOTNOTE[4]. On the squeezed sections - it is not less than 1.5 m.
ENDFOOTNOTE.

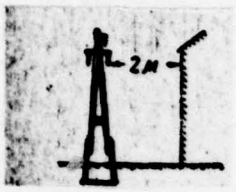


Fig. 26.

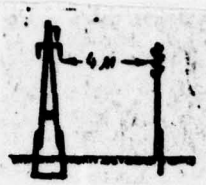


Fig. 27.

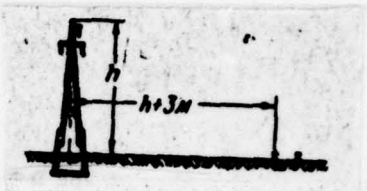


Fig. 28.

Fig. 26. Distance on horizontal from wires about their greatest divergence to dead/blind wall.

Fig. 27. Distance on horizontal from wires by voltage to 1 kg during their greatest divergence to wires with voltage 35 kV.

Fig. 28. Distance on horizontal from wires during their greatest divergence to railway line.

Page 78.

Table 12. Smallest permissible sections of the wires of aerial lines and branchings from them to entrances.

(3) Материал провода	(1) Выше 1000 в (мм²)				(2) До 1000 в			
	(4) В населенной местности и местах пересечения		(5) В населенной местности		ВЛ		(6) Ответвления к вводам в здания	
	ВЛ (7) I класса (выше 35 кв)	ВЛ (8) II класса (1—35 кв)	ВЛ (7) I класса (выше 35 кв)	ВЛ (8) II класса (1—35 кв)	(9) Минимальные одно- и многопроволочные	(10) Максимальные однопроволочные	(11) Минимальные сечения (диаметры) при пролетах (12) до 10 м	при пролетах (13) 10—25 м
(14) Медь	25	25	25	10	6 мм²	16 мм²	2,5 мм²	4 мм²
(15) Сталь	25	25	25	10	∅ 3 мм	∅ 5 мм	∅ 3 мм	∅ 3 мм
(16) Сталеалюминий	25	16	25	16	—	—	—	—
(17) Алюминий и его сплавы	35	35	35	25	16 мм²	—	6 мм²	10 мм²
(18) Биметалл	—	—	—	—	∅ 3 мм	∅ 6,5 мм	∅ 3 мм	∅ 3 мм

Note. In the populated locality and the points of the intersectiopof installations and ways, single-wire wires are not applied.

Smallest permissible sections of the stranded wires of aerial lines in these places: copper - 25 mm² and aluminum - 35 mm².

Key: (1). Is above 1000 V (mm²). (2). To 1000 V. (3). Material of wire. (4). In the populated locality and places of intersection. (5).

In the populated locality. (6). Branchings to entrances. (7). class (above 35 kV). (8). class. (9). Minimum single and multistrand wire. (10). Maximum single-wire. (11). Minimum sections (diameters). (12). with flight/spans to. (13). with flight/spans. (14). Copper. (15). Steel. (16). Steel-aluminum. (17). Aluminum and its alloy. (18). Bimetal.

Page 79.

Table 13.

(1) Условия совместной подвески на общей опоре	(2) Напряжение	(3) Способ подвески	(4) Расстояние между подвешиваемыми проводами	(5) Дополнительные указания
(6) Провода воздушных линий и провода радиотрансляционных цепей	(7) 380/220 *в* и 360 *в*	(8) Провода воздушных линий 380/220 *в* располагаются над проводами радиотрансляционных цепей	(9) Расстояние между нижним проводом воздушных линий и верхним проводом радиотрансляционной цепи не менее 1,5 *м*	—
(10) Провода воздушных линий 1000 *в* и кабели связи и сигнализации	(11) 1000 *в*	(12) Провода воздушных линий 1000 *в* располагаются над кабелем связи и сигнализации	(13) Расстояние между проводами воздушных линий и кабелем связи и сигнализации не менее 1,5 *м*	(14) Металлические оболочки кабеля должны быть заземлены не чаще чем через каждые 250 *м*
(15) Провода воздушных линий I и II классов	(16) 110—220 *кв* и 1—35 *кв*	(17) Провода воздушных линий более высокого напряжения располагаются над цепями низшего напряжения	(18) Расстояния между цепями воздушных линий разных напряжений принимаются в соответствии с требованиями для воздушных линий более высокого напряжения	—
(19) Провода воздушных линий II и III классов	(16) 1—35 *кв* и 0,4 *кв*	(20) То же	(20) То же	(21) При совместной подвеске проводов воздушных линий II и III классов последние должны выполняться по расчетным условиям для воздушных линий класса II. В сетях с изолированной нейтралью 35—0,4 *кв* наведенное напряжение на нейтрали сети 0,4 *кв* не должно превышать при нормальном режиме работы более 10% фазного напряжения сети 0,4 *кв*

Key: (1). Conditions of combined suspension on common/general/total support. (2). Voltage. (3). Method of suspension. (4). Distance between the suspended wires. (5). Supplementary indications. (6). Wires of aerial lines and wire of broadcasting circuits. (7). V and V. (8). The wires of aerial lines 380/220 V are arrange/located above the wires of broadcasting circuits. (9). The distance between the

lower wire of aerial lines and overhead conductor of broadcasting circuit is not less than 1.5 m. (10). Wires of aerial lines 1000 V and the communication cables and signaling. (11). V. (12). The wires of aerial lines 1000 V are arrange/located above the communication cable and signalings. (13). The separation of aerial lines and the communication cable and signalings is not less than 1.5 m. (14). Metal cable sheathings must be grounded not more frequent than through each 250 m. (15). Wires of aerial lines I and of II classes. (16). kV and kV. (17). The wires of aerial lines of more high voltage are arrange/located above the circuits of low voltage. (18). The distances between the circuits of aerial lines of different stresses are accepted in accordance with requirements for aerial lines of more high voltage. (19). Wires of aerial lines II and of III classes. (20). The same. (21). With the combined suspension of the wires of aerial lines II and of III classes, the latter must be made through design conditions for aerial lines of class II. In grid/networks with insulated neutral 35-0.4 kV, the induced voltage on the neutral of grid/network 0.4 kV must not exceed during the normal mode of the work more than 10o/o of phase line voltage 0.4 kV.

Page 80.

Wires must have a reserve of mechanical strength not less than 2

for stranded wires and not less than 3 for single-wire. The reserve of the mechanical strength of stubs and hooks, on which are installed the insulators, must be not less than 2.5 normal stresses of wires even 3 with the weakened stress.

A quantity of insulators on which are assembled the wires, and their type must be selected taking into account the voltage of line, character of route, etc.

The metallic delays, utilized for the stability of the wooden supports of aerial lines by voltage to 1000 V, must be or grounded (earth resistance not more than 10 ohm), or are isolate/insulated with the aid of strain insulator, designed to the voltage of aerial line and established/installed on height/altitude is not less than 2.5 m of the earth/ground.

Cable lines.

By their construction cable lines must correspond to their designation/purpose, operating conditions and to the place of separator.

In the territory of industrial enterprises, the cables are laid in trenches, tunnels and block/module/units (Fig. 29).

Within buildings the cables run themselves either in channels or it is opened directly on constructions and walls of buildings, or in the tubes, laid in sex/floors, floors and engine bases.

The selection of the method of cable laying depends on local conditions.

Separator in trenches is most economical, but in them is embedded the smallest number of cables.

Tunnels are applied in cases when it is required to lay in one direction a large quantity of cables, which is unrealizable with separator in trenches due to a large quantity of different lines of underground communications.

Separator in block/module/units due to its high cost/value is applied in the exceptional cases, for example during intersections with the railway lines and other critical installations.

The cables, run in the earth/ground, must be armored. For protection from chemical effects, metallic to cable sheathing must

have proofing, for example the asphalted winding from fibrous materials.

In collector/receptacles, tunnels, channels, is allow/assumed the separator of unarmoured cables.

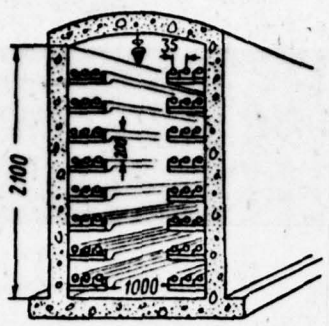


Fig. 29. Cable laying in channels and tunnels, which do not contain water lines, gas line and other pipes.

Page 81.

The surface work of unarmoured cable in electrical locations and production locations is allow/assumed at height/altitude not less than 2 m. In the case of the arrangement/permutation of cable at the lower altitude, is required the enclosure/protection of cable by tubes, by angle iron and so forth of mechanical damages.

In production locations the cables must be available for a repair, and is opened laid - for an inspection; they must be laid so that impossible would be the mechanical damages. The housings of the cable boxes, end funnels, shielding metal cable sheathings, armor must be grounded.

With cable laying in production locations above armor or metal cable sheathing must not be of proofings from fuels, fibrous and to that of similar substances.

With the surface work of outside buildings, under the open mounting fixtures, over the incombustible surfaces must be applied the cables with external proofing (usually from polyvinyl chloride).

In locations with agressive medium, must be applied, as a rule, cables in polychlorovinyl, lead and other shells depending on the character of medium.

In locations, channels, shaft/mines, tunnels, collector/receptacles and so forth the cable laying is allow/assumed only without external proofings from combustible fibrous substances (asphalted jute). To avoid the decomposition of cables metal cable sheathings should be cover/coated with the layer of bituminous or anticorrosive composition.

With cable laying in channels, the size/dimensions of the latter must be sufficient in value in order to ensure the correct mounting of cables and their normal operation (Fig. 30).

Cables must be packed by constructions in channels with the depth of the latter 0.5 m. Is allow/assumed also their separator, also, on the bottom of channel. With separator on the bottom of the channel of power cables by voltage it is above 1000 V and control cables the distance between them must be not less than 100 mm; in channels is allow/assumed the separator of unarmoured cables of small sections VRG and SRG. The charging of the cables, laid in channels, by sand is forbidden.

Cable ducts must overlap flush with sex/floor with stripper plates from the incombustible material. This overlap is made either on an entire route or depending on local conditions only on the individual sections where is necessary control/checking, for example in the places of coupling or branch joints.

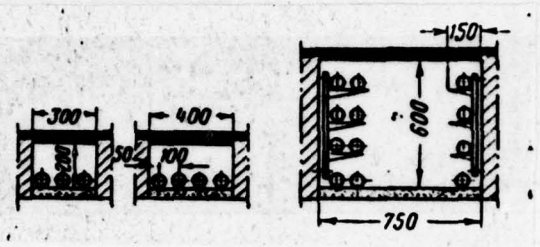


Fig. 30. Separator of power cables in channel.

Page 82.

In the latter case only in control places is arranged a sufficient according to size/dimensions detachable overlap, in order to produce the necessary repair and inspection.

In the places where is possible the incidence/impingement of molten metal, liquids with the high temperature or substances, the destructively operating on metal cable sheathings, equipment/device of cable ducts with detachable overlaps, and also hatches in collector/receptacles and tunnels are not allow/assued.

Cable laying in sex/floor and floors must be conducted in channels or pipes. The seal in them of cables tightly is not allow/assumed (Fig. 31).

Channels, tunnels, collector/receptacles are shielded from the penetration in them of ground water by the means of drainages, location of the channels higher than ground water; in collector/receptacles and tunnels with automatic the starting/launching of drainage mechanism depending on water level.

Between the cables also of various kinds by turboconductors it is necessary to maintain/withstand the determined distances; as a rule, it must be not less than 0.5 m, and with petroleum- and by gas pipe - is not less than 1 m. With separator in the earth/ground, the cables, located from conduit/manifolds at a distance are less than 0.25 m, for all extent/elongation of approach, they must be laid in tubes.

With surface work in production locations, the clearance between power cables with voltage to 1000 V must be 35 mm, among cable voltage are above 1000 V and cables by voltage to 1000 V - 250 mm; among cables and different conduit/manifolds - it is not less than 0.5 m.

The distance between suspension points of cable or attachment of brackets must be with horizontal separator for power cables not more than 1 m, for controls - it is not more than 0.8 m; with the vertical run for power cables - it is not more than 2 m, for control cables - are not more than 1 m (Fig. 32).

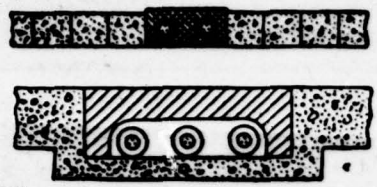


Fig 31.

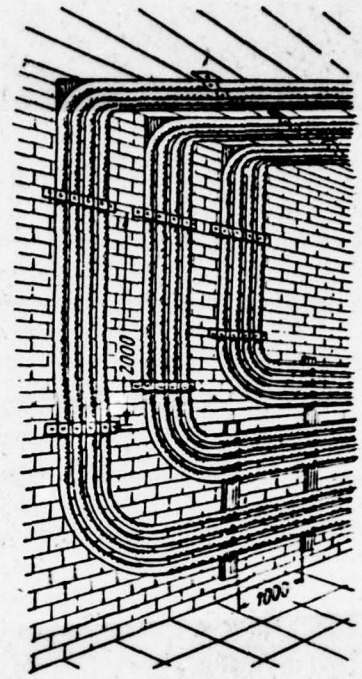


Fig 32.

Fig. 31. Separator of pover cables in sex/floor of building in tubes.

Fig. 32. Separator of pover cables on walls.

Page 83.

Radii of the internal curve of the curvature of cables must have with respect to the outside diameter of the cables of multiplicity not less:

a) power single-cable from the paper saturated insulations, in lead shell, armored and not armored - 25;

b) power multiple with impoverish-saturated insulation in lead covering, armored - 25;

c) the power multiple and control cables with paper saturated insulation in lead or aluminum shell, armored and not armored - 15;

d) the power and control india-rubber cables, in lead or polychlorovinyl shell, armored - 10, not armored - 6.

In the relation to dimensions, the collector/receptacles, tunnels and the arrangement/permutation in them of cables must satisfy the established/installed requirements.

For descent into tunnels, collector/receptacles long than 7 m compulsorily equipment/device from the opposite end/leads of two outputs, for which are provided for constant, safe and convenient staircases. The overlaps of hatches for descent into draw-in pits, tunnels, collector/receptacles must be flush with sex/floor, they must not spontaneously be closed. Tunnels and collector/receptacles

are equipped by ventilation, by general illumination by voltage not above 36 V and repair illumination 12 V.

In collector/receptacles is allow/assumed the laying of cable lines together to by communication cables, water, heat- and by air ducts with the observance of following conditions (Fig. 33):

a) with double-row location on the one hand of passage they must be laid from above communication cables, hearth by them - heating mains; on the other hand of passage, - on top power cables, below - water pipes;

b) with single-row location must on top be laid power cables, hearth by them - communication cables, hearth by them - water and heating mains;

c) power cables must be separate/liberated from control communication cables by the horizontal incombustible partition/baffles.

The combined laying of cable lines with gas pipes and the conduit/manifolds, which contain the easily ignited and flammable liquids, and also with the conduit/manifolds of fire-fighting water supply is forbidden.

2. Open transformer substations.

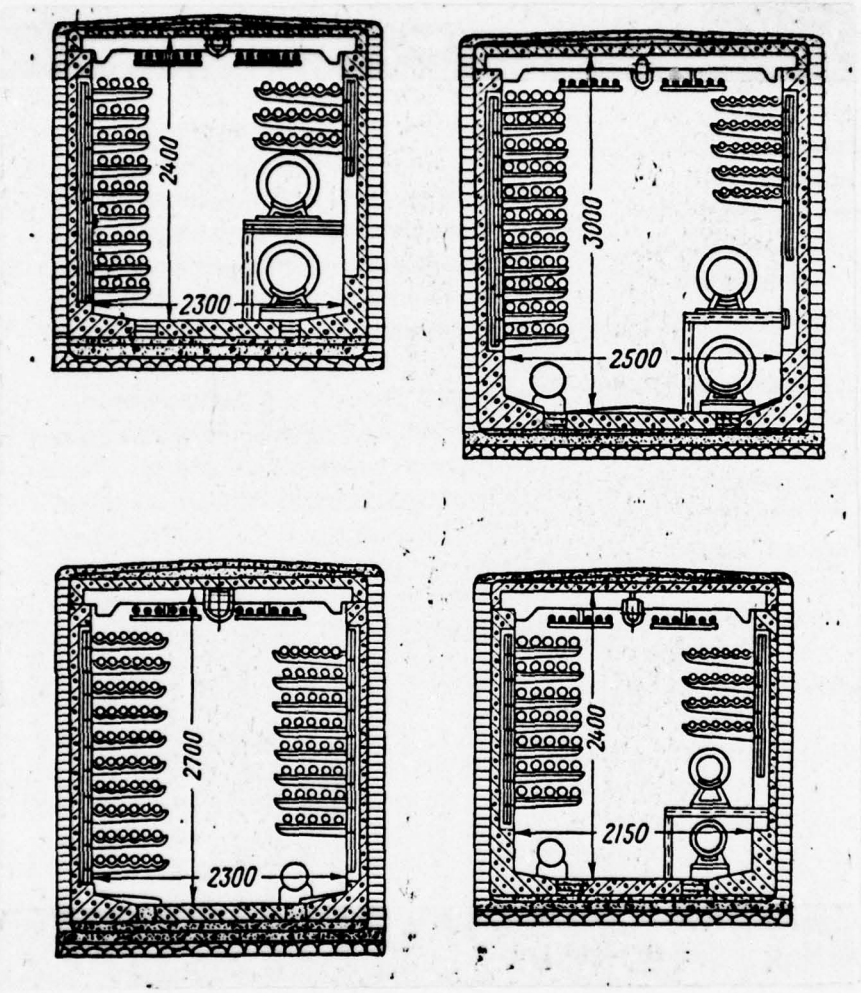
The territory of substation must be protect/surrounded. The height/altitude of the external enclosure/protection of territory must be not less than 2.5 m. Furthermore, openly established/installed transformers and the open distributors in the territories of industrial enterprises must be additionally protect/surrounded by the means of the mesh or mixed enclosure/protections not less than 2 m in height.

Page 84.

Equipment/device of enclosure/protection not is compulsory for the closed substations, arrange/located in enclosed guarded territory, or mast (column) substations (Fig. 34).

In the case of the open setting up of transformers near buildings, are provided for the enclosure/protections by their on top continuous flooring or durable meshes to avoid the incidence/impingement of snow and different object/subjects with purification/cleaning, the repair of the roof of the adjacent building (Fig. 35).

Fig. 33. Cable laying in collector/receptacles.



Page 85.

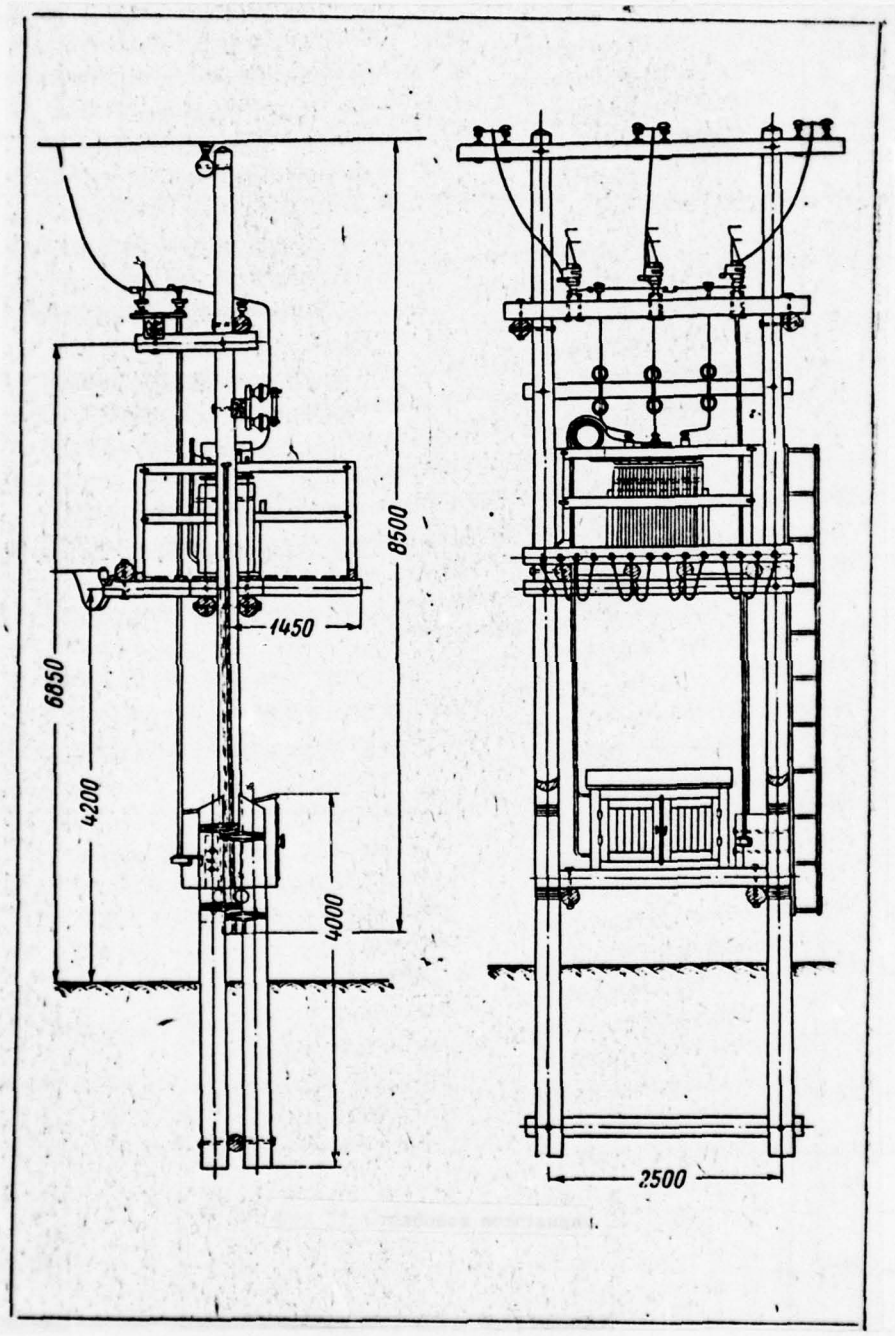


Fig. 34. Column substation.

Page 86.

The smallest permissible clearances with the rigid set of tires between the current-carrying parts of the set of tires of different phases or with respect to the grounded parts and to the earth/ground are shown in Table 14.

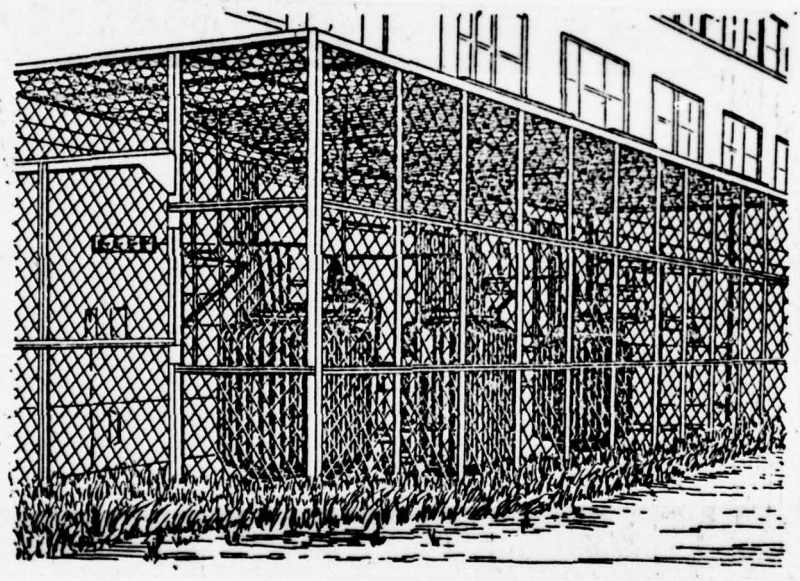


Fig. 35. Enclosure/protection of transformers, establish/installed of external wall of building.

Table 14.

(1) Расстояние в свету от токоведущих частей одной фазы в *см*	(2) Номинальные напряжения в *кв*			
	(3) 10 и ниже	20	35	110
(4) До токоведущих частей других фаз	20	30	40	—
(5) До заземленных частей	20	30	40	—
(6) До постоянного ограждения:				
(7) барьера	100	100	100	175
(8) сетки	25	30	40	100

Notes. 1. At flexible set of tires, taking into account possibility of decrease of distances between independent phases under effect of wind, temperature or ice-covered surface, they increase them to value of approach. So, with the location of flexible set of tires in one horizontal plane the value of the distance between phases, keeping in mind the possibility of their approach, they determine according to formula

$$l_1 = l + k\sqrt{f},$$

where l_1 is a distance between the phases taking into account the approach of set of tires in cm; l - distance in the case of rigid set of tires in cm; k - coefficient for copper and its alloys, equal to 7.5; for aluminum and its alloys, equal to 10; f is maximum deflection in cm.

2. Enclosure/protection of current-carrying parts, arrange/located at height/altitude 3 m with voltage 35 kV and 3.75 m with voltage 110 kV from level of planning of earth/ground, is not necessarily.

Is forbidden the wiring of overhead conductors of lighting lines, lines of communication/connection and signaling above the current-carrying parts of the open distributor and hearth by them.

Key: (1). Clearance from the current-carrying parts of one phase in cm. (2). Nominal voltages in kV. (3). and it is below. (4). To the current-carrying parts of other phases. (5). To the grounded parts. (6). Before constant enclosure/protection. (7). barrier. (8). mesh.

3. Closed transformer substations and distributors by voltage are above 1000 V.

Requirements for location.

The locations of substation and distributors must be unavailable for extraneous persons, for this purpose serve the enclosure/protections of territories and equipment/device of the proper locks. If substation is found on the territory of the guarded enterprise that of the special enclosure/protection of substation it is not required.

Buildings and the locations of closed substations and distributors must satisfy fire-fighting norms both in the relation to equipment/device itself and in the relation to fire-fighting disruptions.

Substations and distributors can be decent to buildings with the inconbustible walls, and are also built in inside the fundamental and

auxiliary locations of productions, which relate to categories G and D according to the operating fire-fighting norms of the construction design of industrial enterprises and populated places.

It is forbidden to arrange substation and distributors under locations with wet technological processes, under shower-baths, by restrooms, baths, near the locations, intended for people's mass assemblies.

The locations of substations and distributors must be separated from official and other locations by walls and overlaps.

Distributors (Fig. 36) with voltage 1000 V and above must be arrange/located in separate locations; their arrangement/permutation in common/general/total location is allow/assumed if substation and distributors are operated by one organization and are service/maintained by personnel, allowed to works in settings up by the voltage above 1000 V and having the appropriate qualification.

Intrashop substations can be placed in the fundamental and auxiliary locations of the productions which are related to categories G and D. Level weeding substations it must be identical, it is not lower than the level of the sex/floor of shop (with step-by-step gradient to the side of the oil sump pits).

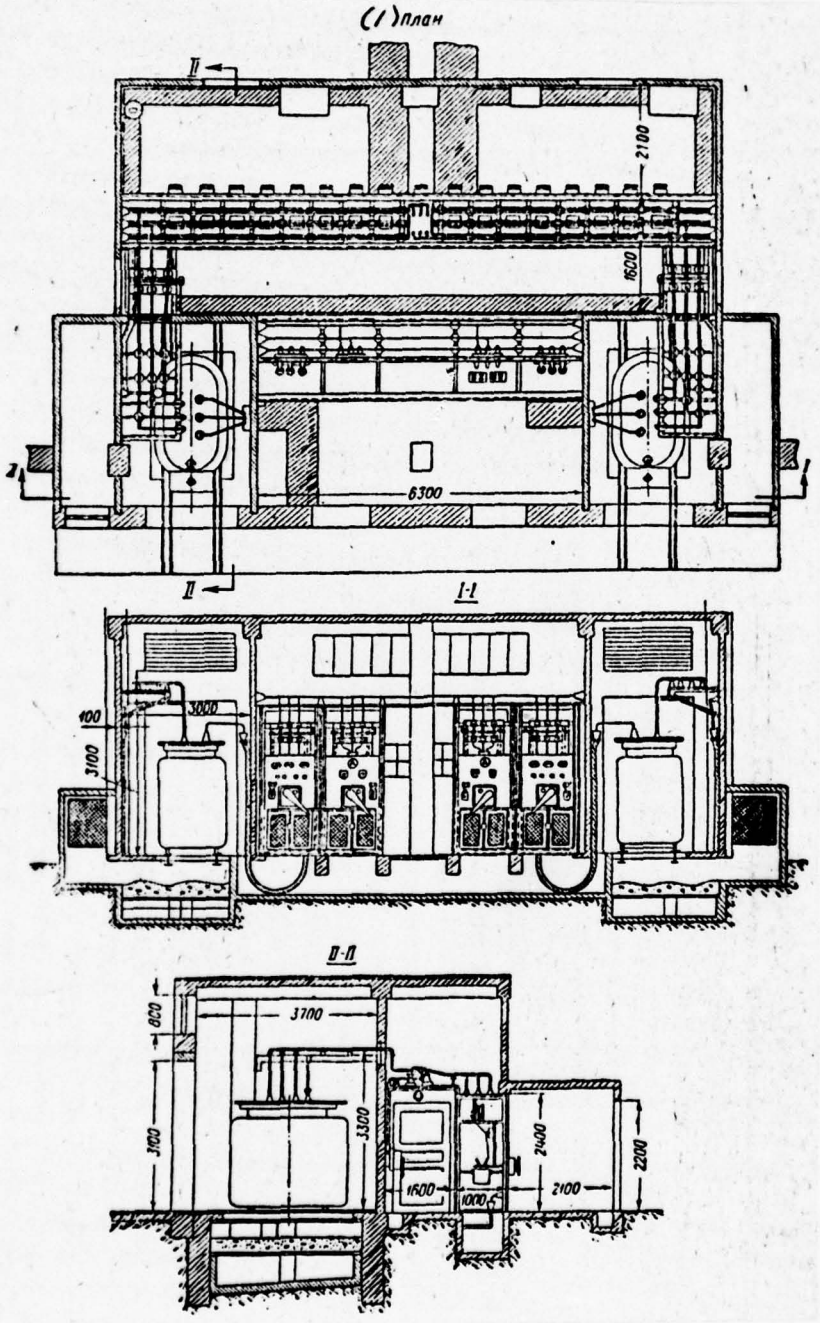

(1) План
II
2100
1600
6300
II
I-I
100
3000
3100
II-II
3700
800
3100
3300
2400
2200
1600
1000
2100

Fig. 36

Fig. 36. Distributors by voltage to 1000 V are above 1000 V.

Key: (1). Plan/layout.

Page 89.

Windows are allow/assumed only in distributors, which are found on the protected/surrounded or guarded territories. All windows of the first landing must be shielded by wire gauze.

Equipment/device of windows in intrashop substations and in the locations of distributors is forbidden.

Output from the locations of substations and distributors is allow/assumed only into the locations whose productions are related to categories G and D.

The width of passages about the walls of the intrashop substations of those having doors or vent holders, must be not less than 1 m.

In the locations where is located equipment under voltage, doors must be open/disclosed outside or into other locations; doors are

supplied with the locks, which are open/disclosed from within without key/wrench. Among the locations, which contain equipment under voltage it is above 1000 V, doors they must be open/disclosed to both sides. When, indoor, the oil-filled equipment of door is present, they make incombustible or poorly combusted.

At the length of distributive device more than 7 m there are placed not less than two outputs on the end/leads of the location of distributor. Equipment/device of thresholds in doors is forbidden.

In distributors with tank switches, the explosive corridors are equipped by outputs outside or to staircase.

For the prevention of the possibility of the penetration of ground water into distributors and a substation, into tunnels, basements, the cable ducts so forth must be accepted the corresponding measures. So that water would not fall on input/introduction and the insulators of the roof above substations and distributors are equipped by drain grooves and tubes.

Dimensions of location must correspond to the dimensions of the adjustable equipment taking into account the necessary passages, service platforms, the staircases, which ensure safe operation and the safe production of repair-assembling works under normal and

energency conditions.

Walls and the ceilings of locations must be those who were becone white; the panels of the chambers of switches from the corridor of control must be painted in light tones, and doors and window frames, metal constructions are covered with oil paint.

Locations must be dry. In locations with constant attendant personnel, must be supported normal temperature (not below +16°C).

For the safe execution of operations according to control and observation of readings and the action of instruments, must be well illuminated the distributors and panels, and also passages from rear side for their maintenance, separate work sites and area/sites.

Page 90.

It is necessary, in order to the value of the illumination of the locations of substations and distributors satisfied the operating norms of artificial illumination.

The safety of the maintenance of lighting plants in the locations of substations and distributors is achieved by the sufficiently removed arrangement/permutation of illuminating lamps

from current-carrying parts, which are located under voltage above 1000 V, for example by the application/use of wall light fixtures and by the possibility of the disconnection/cutoff of the half of illuminating lamps from under voltages. During the use of illuminating lamps of suspension construction of the type "Lyucette", "Opal spheres", etc. must be provided supplementary safeguards for the exchange of tubes and cleanup of armature without stress relieving from setting up, for example the use of special staircases with the protected/surrounded area/site.

Substations and distributors must have telephone communication.

Transformer locations must be shielded from the incidence/impingement of snow and rain. The doors of all transformer locations must be incombustible or those who are poorly combusted and be open/disclosed outside or into another location. The doors of transformer locations must be closed to lock.

On walls transformer indoors and on the jacket of transformer must be the clear labels, which indicate the reference number of transformer, the power and the voltage; on doors is indicated only reference number; on the tanks of single-phases transformer, is given the coloring with respect to the phases: A is yellow, B - green, C - red.

On the doors of transformer locations, must be solidly fastened the poster "voltage - it is dangerous for a life" or "under voltage, it is dangerous for a life" !.

Transformers must be installed in the chamber by the conclusions of high voltage to the wall, opposite to input door, or by conclusions to one of the lateral walls. In this case, must be observed the following distances:

- at the power of transformer to 100 kVA - it is not less than 0.3 m to walls and not less than 0.8 m to input door;

- at the power of transformers of more than 100 kVA to 1000 kVA with respect to 0.6 and 0.8 m, also, at the power of transformers of more than 1000 kVA -1m up to walls even 1.5 m up to input door.

The transformer chambers must have the natural ventilation, which ensures the normal temperature conditions of transformer. Sometimes is allow/assumed the equipment/device of mechanical ventilation.

On the expander of transformer, must be establish/installed oil

meter glass. On the tank of expander, must be plotted/applied three reference marks, which correspond to oil level at temperatures of -35, +15, +35°C.

Page 91.

Fittings and switches in the chambers of transformers must be installed directly before the barrier, further possible from the side of higher voltage of transformer and at available height/altitude for the replacement of tubes without the use of staircases. The setting up of the fittings above the input door is forbidden.

Distributors. In the places of the passage of cables, the openings in floors and partition/baffles must be closed and are consolidated by the incombustible materials. All external opening/apertures are installed or are closed by louver or meshes.

Cable ducts in distributors must overlap into level with hollow of location with the stripper plates, made from the metal, the reinforced concrete and other incombustible materials.

The explosive corridors, and also the corridors of the maintenance of the chambers, which contain the electrical equipment, oil-filled or compound, during substations with constant attendant

personnel must be equipped with the emergency exhaust ventilation, included from without and the not connected with other ventilation installations substation or shops.

The drives of switches, which allow/assume manual control, for the preservation of personnel, which operates similar switches, must be separated from switches by shielding wall or metallic panel.

For the prevention of incorrect operation by disconnectors under load all disconnectors must be blocked with the appropriate switches.

With single-pole disconnectors the blocking must be realize/accomplished between switch and the enclosure/protections of disconnectors. The drives of disconnectors must have a device for a closing to lock.

Auxiliary contacts on the shaft of switches and disconnectors must be establish/installed in the places, available for the safe inspection without the disconnection/cutoff of equipment.

The busbars of distributing equipment/devices must have coloration, provided for by GOST: phase A is yellow, phase B - green and phase C is red.

Masonry panels or the doors of the chambers and electrical equipment of distributors must be equipped by the clear labels, which indicate the designation/purpose of connection.

Furthermore, indoor of distributor on the appropriate places must be hung out the posters on safety engineering according to the requirements for the rules of use and testing protective agents, used in electrical installations, and also the rules of rendering of first aid during damage/defeats by electric current and accordingly to the diagrams of installations themselves.

Page 92.

In the chambers of distributors, and also in other places (in transformer chambers), where can arise the need for shorting and grounding of current-carrying parts for the safe production on them of the repair or other works, must be prepared the cleaned and tinned contact surfaces for the imposition of movable shielding groundings.

The armature of electrical illumination must be establish/installed so that would be guaranteed its safe maintenance (exchange of tubes, dusting and so forth).

Requirements for electrical safety.

The intersection of the chambers of transformers and equipment by cables and the wires, which relate to extraneous electrical circuits, is forbidden.

In distributors it is necessary to ensure the possibility of the safe and visible disconnecting of the apparatuses of each circuit from the collecting mains and from other electric power sources.

Disconnectors must have blockings with the appropriate switches, establish/installed in the same circuit, independent of their location - in one or different locations.

Near the equipment of distributor and substation, on the panels of the chambers of switches, the transformers of power, lighting, voltage transformers, on doors from external and inside upon the input into the chambers, which contain switches, transformers, etc. - it is necessary to make the durable and clear labels, which indicate designation and the designation/purpose of separate feeders, switches, transformers.

On all switches must be the clear designations of positions

"included" and "it is disconnected". Besides labels, expedient to apply conditional coloration in the drives of switches for a position "it is included".

For the light/lung discrimination of the parts, which relate to of different kind to currents and voltages, is provided for distinctive coloration. Set of tires during substations and in distributors is painted in color, accepted according to the Gost.

Besides designation for the designation of the position of switch (" it is included" or "is disconnected"), switches are supplied with signaling equipment/devices in the form of the red and green lights, adjustable on the panels of cells from the maintenance of switches.

In this case, must uniformly be applied primary colors: for a position "it is included" - red color (lights up red light) and for a position "disconnected" - green color (is fired the green light).

In all sites of installation, where subsequently in repair work can be required the imposition of time/temporary groundings, contact surfaces on current-carrying parts they make those who were cleaned and tinned; on the stationary grounding equipment/devices are establish/installed special terminal/grippers in the form of wing nut

or bolt for the connection to them of movable groundings.

Page 93.

The bare current-carrying parts are shielded from the random touch by their arrangement/permutation in the chambers, protect/surrounded properly, in such a case, when current-carrying parts are arrange/located at height/altitude from floor level: less than 2.5 m with voltage to 10 kV inclusively, it is less than 2.75 m with voltage from 10 to 35 kV even 3.5 m with voltage 110 kV.

The oil breakers in the explosive and open chambers are arrange/located so as in the absence of voltage on parts, which are located in the chamber, to ensure convenient admission for all necessary works on repair and the revisions of the oil breaker and other equipment components.

Furthermore, must be convenient admission to the oil breakers both in the absence and in the presence of the voltage in the chamber - for observation of oil-level gauge, after the mechanical and light position indicators of the oil breaker, its drive, sets of tires, and also all other equipment components, arrange/located in the chamber.

The open chambers are equipped by the mesh or mixed

enclosure/protections not less than 1.7 m in height the size/dimension of sieve mesh not more than 2 x 2 cm. Enclosure/protections have devices for their closing.

Sometimes the mesh and mixed enclosure/protections of the chambers of the oil and other switches whose housings normally are located under voltage, it is expedient to equip with the blocking, which blocks the input into the chambers until is completely removed voltage.

During all enclosure/protections must be solidly fastened the posters, that warn about the danger of touch to current-carrying parts, for example: "under voltage - it is dangerous for a life", etc.

Barriers cannot be considered enclosure/protection for current-carrying parts; therefore they are utilized only as supplementary means of enclosure/protection from approach/approximation to electrical equipment when it is not required to perform any operations with equipment or to take reading of instruments. If current-carrying parts in the chambers are arrange/located below 2.5 m of the level of the sex/floor and chamber have continuous enclosure/protections or doors, then within the chamber directly behind input door is establish/installed the wooden

barrier with a height/altitude of 1.2 m. Barriers are utilized also before the assemblies by the voltage above 1000 V in electrical locations.

The dimensions of electrical safety (in cm) - the distance between current-carrying parts, current-carrying parts and enclosure/protections, the constructions of buildings must be not less indicated in Table 15.

The current-carrying parts, arrange/located above passages, it is possible not to guard, if their height/altitude above the sex/floor in installations by the voltage to 10 kV composes not less than 2.5 m, also, in installations by the voltage from 10 to 35 kV inclusively - 2.75 m and with 110 kV - 3.5 m.

Page 94.

In the production of works in distributors, are establish/installed time/temporary enclosure/protections, moreover distances from current-carrying parts to enclosure/protections must be following: in installations by the voltage to 66 kV inclusively - not less than 35 cm, in installations by voltage from 10 to 35 kV inclusively - are not less than 60 cm and in installations by the voltage 110 kV - 150 cm.

Cubic switchboards and substations.

The locations of the distributors and corridors of maintenance must have passages, sufficient on width and height/altitude. It is not possible to encumber passages by different object/subjects in order not to create the interferences during maintenance and repair of distributors.

In the case of the absence in the corridor of the maintenance of the drives of switches, disconnectors, the width of passages during the one-sided arrangement/permutation of equipment must be not less than 1 m, and during the two-way arrangement/permutation of equipment, - it is not less than 1.2 m.

When there is present in the corridor the maintenance of the drives of switches and disconnectors with one-sided arrangement of equipment the width of passages must be not less than 1.5 m, during the two-way arrangement/permutation of equipment, - it is not less than 2 m.

Table 15.

(1) Габариты	(2) Напряжение в кв					
	1—3	6	10	20	35	110
(3) Расстояния между токоведущими частями разных фаз, а также между токоведущими частями и заземленными конструкциями и частями зданий	7,5	10	12,5	18	29	—
(4) Расстояния между токоведущими частями и ограждениями:						
(5) сплошными	10,5	13	15,5	21	32	75
(6) сетчатыми	17,5	20	22,5	28	39	82
(7) барьерами	50	50	50	70	80	—
(8) Расстояния между токоведущими частями, расположенными над барьерами и вертикальной плоскостью, пересекающей барьер, при расположении токоведущих частей над барьерами на высоте от 1,2 до 1,7 м	50	50	50	70	80	150
(9) То же на высоте над барьерами от 1,7 до 2,3 м	17,5	20	22,5	28	39	82

Key: (1). Dimensions. (2). Voltage in kV. (3). Distances between the

current-carrying parts of different phases, and also between current-carrying parts and the grounded constructions and the parts of buildings. (4). Distances between current-carrying parts and protections: (5). continuous. (6). mesh. (7). barriers. (8). Distances between the current-carrying parts, arrange/located above barriers and the vertical plane, which intersects barrier, with the location of the current-carrying parts above barriers at height/altitude from 1.2 to 1.7 m. (9). The same at the height/altitude above barriers from 1.7 to 2.3 m.

Page 95.

Cubic switchboards (KRU) (Fig. 37 and 38) and ganged transformer substations (KTP) can be establish/installed in separate locations with the production of categories G and D. Cubic switchboards with tank switches are establish/installed in production locations on the condition that the number of switches will be not more than two and a quantity of oil in each of them - is not more than 60 kg.

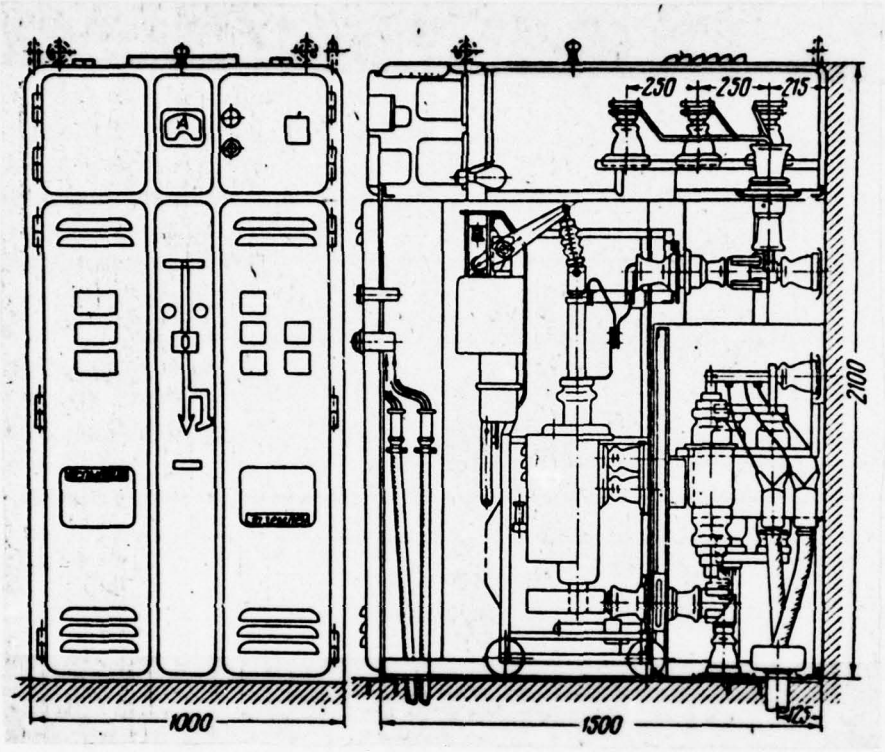
All current-carrying parts KRU and KTP, adjustable in the locations into which they have an admission of people, pasts of instruction, are closed by continuous coatings from the incombustible material and are placed on those who were protect/surrounded by

meshes the sections of location. During the installation of KRU and KTP in damp/crude and dusty locations with adverse medium, their jackets must have packing/seals against the effect of the environment.

Ultimate capacity of KTP with tank transformers - is not more than 750 kVA.

In the locations, operated by the tap/cranes, the telphers and other lift trucks, KRU and KTP are placed by such shape, in order to after being excluded the possibility of their damage in the work of lift conveying appliances.

Fig. 37. Cubic switchboard 6-10 kV with switch VHG-133 of plant "electrical shield".



Page 96.

Battery installations.

The requirements, imposed on equipment/device of battery installations, are propagated to acid and alkaline batteries and consist in the following.

Stationary storage batteries must be establish/installed in the specially intended for them locations with the input within the reel. Batteries by voltage 24-28 V can be establish/installed in the ventilation cabinets.

The arrangement/permutation of acid and alkaline batteries in one location is forbidden.

The walls, the ceiling, the doors and the sashes, the ventilation ducts, the metal constructions, the shelves and other

parts of the locations, which contain acid storage battery/accumulators, periodically one should paint with acid-resistant paint; ventilation ducts (air ducts) must be painted both from external and from inside. Treatment/working by the acid-resistant paint of the locations of the alkaline batteries is not required. Shelves are painted with bituminous paint.

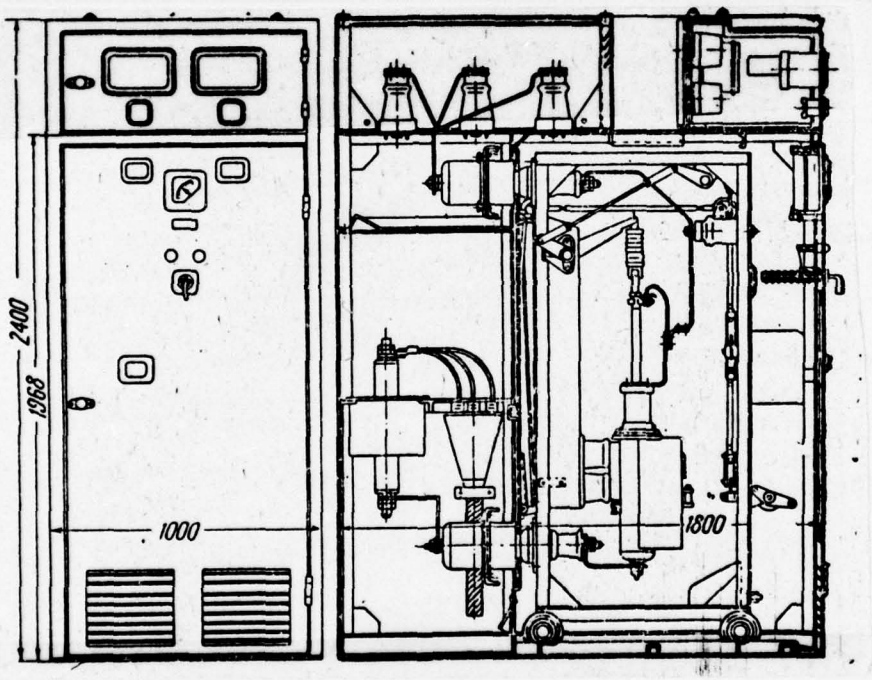


Fig. 38. The cubic switchboard of the plant HEP with a switch of the type VMG-133.

Page 97.

The locations of storage batteries must be equipped with suction and exhaust ventilation separately for acid and alkaline batteries with the suction of gas from the upper and lower parts of the location. The conclusion of air ducts into chimneys and common/general/total ventilation system is forbidden. The locations in which are located the movable storage battery/accumulators, working only in the mode/conditions of discharge, by special ventilation they are not equipped.

The heating of battery location must be made with the aid of the calorific equipment/device, arrange/located battery outdoors and feeding warm air into air duct. Is allow/assumed equipment/device of steam or hot-water heating battery indoors in the form of one-piece/entire wrought pipes without collars and cores.

With furnace heating the furnace and furnace opening/apertures must be located battery outdoors, but emerging and battery location the warming side of furnace must be shielded as metal casing and not have vents. Installation in the battery location of electrical

circuits is forbidden.

The temperature in battery location must be not below +10°C.

For windows in battery location, must be applied the frosted glasses, covered with white paint; for illumination - illuminating lamps of explosion proof construction. Switches, plug rockets and safety device/fuses must be establish/imstalled battery outdoors. Electric wiring is made by wire in acid-resistant and alkali-resistant shells.

On the doors of battery location, must be the labels: "battery room", inflammable", " When lit de not enter", "Do not smoke".

The doors of battery location must have the self-locking lock, which is freely triggered from inside without key/wrench. Location must be constantly closed.

To accept food and to smoke in battery room is forbidden.

4. Distributors and panels by voltage to 1000 V.

Distributors can be in the form of the panels (Fig. 39) or of the cellular type or in the form of the assemblies, comprised of the control boxes (Fig. 40), or assemblies of panels in cabinets (Fig. 41), prepared from the incombustible and poorly combustible materials. The construction of distributors must correspond to its designation/purpose, site of installation to environmental conditions and operation.

The nonpolished surfaces of marble, slate and other insulation, utilized for the panels of distributors, by the appropriate methods are shielded from the penetration in them of moisture.

Page 98.

The distributors, adjustable outside electrical locations, must be shielded from random touch to current-carrying parts or the incidence/impingement on them of foreign objects, moisture and dust. This protection is realize/accomplished by means of the locking cabinets and jackets from the incombustible material. In production locations, at least and on the protected/surrounded sections, the setting up of distributors with the unprotected current-carrying parts is not allow/assumed.

In locations without the increased danger, can be

establish/installed on height/altitude more than 2.5 m the panels without protective housings on the condition that the location of panels excludes the possibility of random to them touch and incidence/impingement on them of any object/subjects.

The distributing frames, equipment/devices and their separate cabinets must be equipped by the easily read labels, which explain the designation/purpose of the connected wires and cables with the relating to them switches, safety device/fuses by measuring meters; must be shown also the section of wires and cables and the rated current of safety device/fuses.

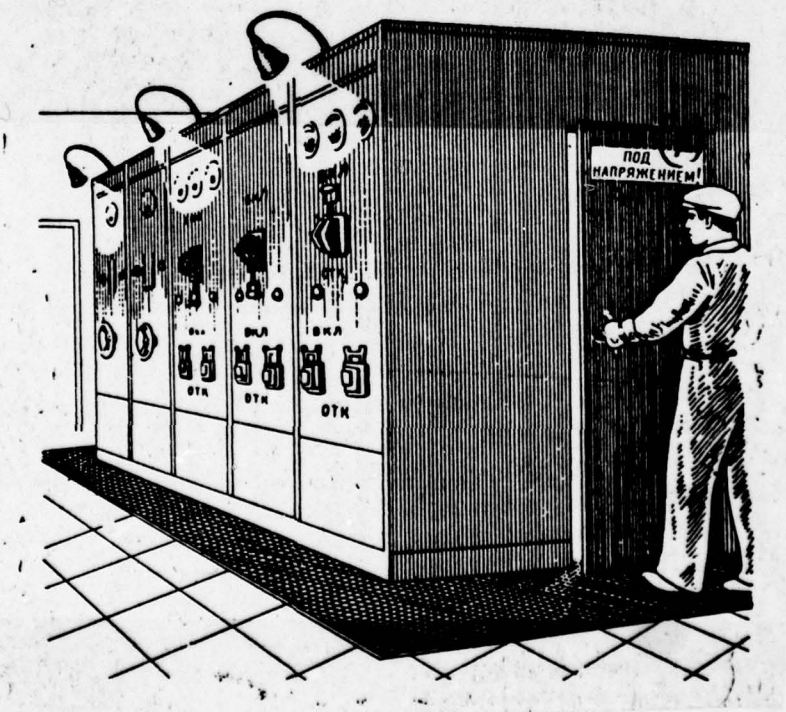


FIG. 39.

Fig. 39. The distributing frames.

Key: (1). Under voltage!.

Such labels are made both from the control and within separate chamber panels.

Safety device/fuses, the switches and all instruments, intended for the interruption of current, must be easily attainable for maintenance and at the same time are arrange/located so that would be eliminated the danger of the electrotraumas of the service personnel, and also the possibility of inflammation or damage of the surrounding object/subjects either of the part of the distributor and onset of short circuit or closing/shorting to the earth.

The knife switches, adjustable on the face of anelboards, and also on panels, must be shielded by jackets from the incombustible or poorly combustible material without slots for displacing the handle (Fig. 42) or applied knife switches with lever control (Fig. 43).

Setting up on the face of the distributing frames of knife

switches and safety device/fuses with the unprotected current-carrying parts is forbidden.

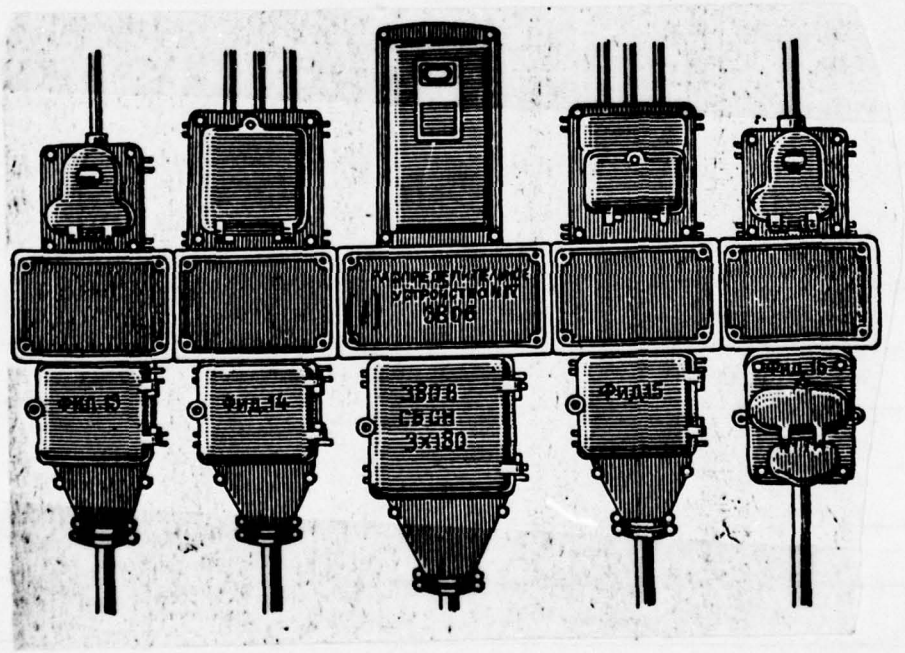


Fig. 40. Distributor by voltage to 1000 V, comprised of the control boxes.

Key: (1) Distributor.

Page 100.

On the face of the open panels of the distributing frames, it is possible to establish/install only protected cutouts (Fig. 44). Tubular type safety device/fuses must be establish/installed from the back of panels. The setting up of tubular safety device/fuses on face is allow/assumed under the condition of the arrangement/permutation of the panel itself in the locking cabinet (Fig. 45).

The control boxes, adjustable outside electrical locations, are supplied with blocking between the door and the knife switch.

Knife switches, automatic air circuit breakers and disconnectors are establish/installed on the distributing frames and in the control boxes in such a way that in the extended state their moving elements could not render/show under voltage. Exception are: knife switches, automatic switches and disconnectors in in parallel working circuits; the knife switches, which feed panel and adjustable on one panel in a series with the knife switches of the outgoing feeders and also the

knives of switches.

In one and the same setting up the motion of handles, handwheels and drives of the including apparatuses must be conducted as far as possible in just one direction.

The setting up of stopper safety device/fuses is conducted so that with the removed plugs the screw sockets of safety device/fuses could not render/show under voltage. Safety device/fuses are establish/installed after switches, counting on feeding stroke of energy, so that the exchange of the fuse links could be conducted by the removed voltage.

The arrangement/permutation switchgear (switches of safety device/fuses) must provide the possibility of the safe production of repair on separate circuits (on the separate cables of distributors).

The smallest distances between by motionlessly fastened the locating under voltage, bare parts of different polarity, and also among them and the uninsulated metallic parts of distributors or the parts of buildings must be not less than 30 mm over the surface of insulation and not less than 15 mm by air.

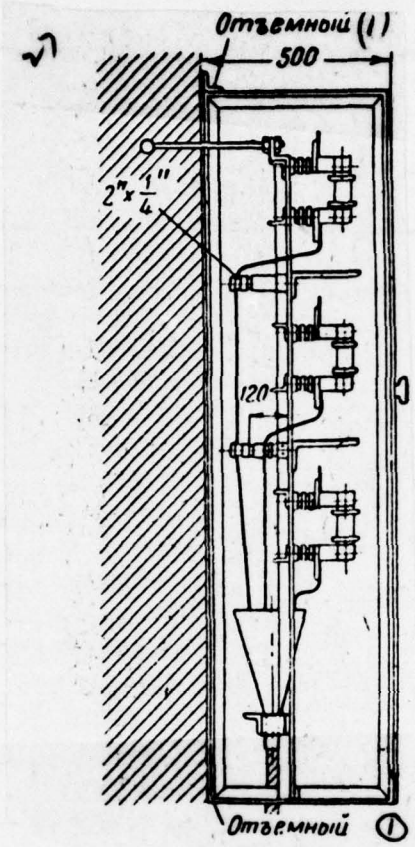


FIG. 41

Fig. 41. Common/general/total metal cabinet with equipment for electrical power distribution.

Key: (1). Detachable.

Page 101.

Exception/elimination is allow/assumed for the lighting panels where these distances can be respectively decreased to 20 and 10 mm. Distances indicated above smallest permissible of the surface of insulation can be accepted only under the condition of applying of guards and cabinets of such construction which reliably shields the insulating parts from contamination.

One should avoid the intersections of current-carrying parts. Current-carrying parts must be reliably insulated in the points of intersection or driven out from each other up to distance not less than 15 mm and to fasten in such a way that their approach it would be impossible. Intersections one should make the hearth of angles 90°.

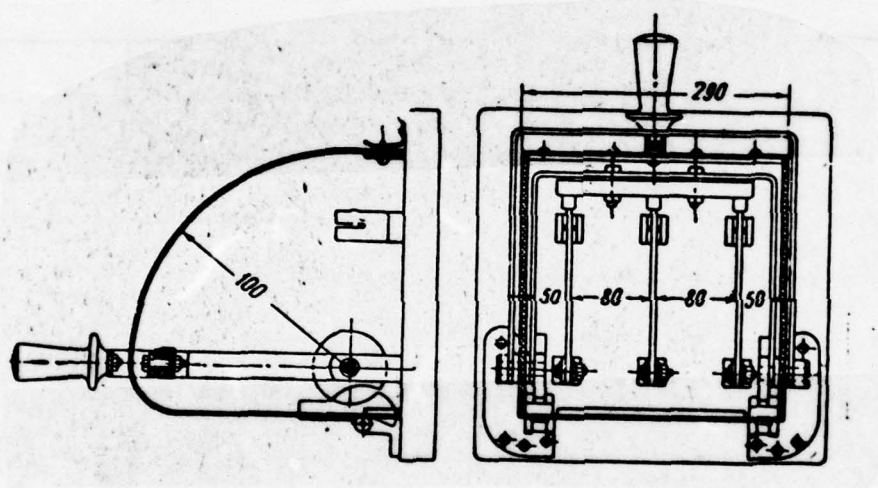


Fig. 42. Knife switch in protective housing.

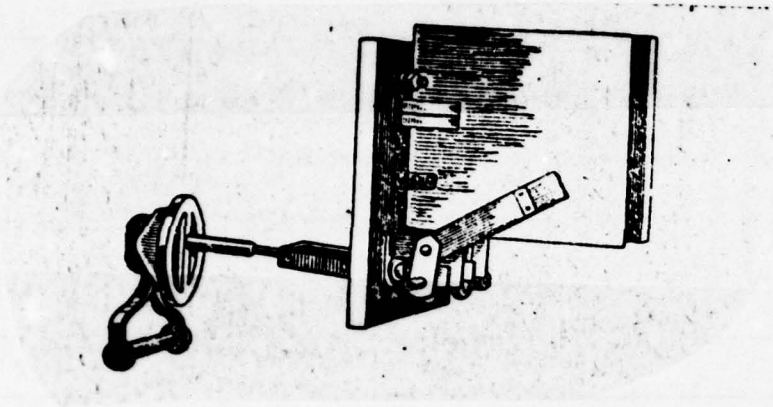


Fig. 43. Knife switch with lever control.

Page 102.

Quality and the thickness of the layer of insulation must be located in accordance with the nominal voltage of setting up.

Signal lamps must be available for their replacement from the face of distributors.

For the maintenance of the distributing frames and equipment/devices from their face and backs are made the passages or the area/sites, which ensure convenient control and observation of the readings and signaling tubes.

The smallest permissible in world/light width of passage is 0.8 m at height of passage not less than 1.9 m.

In passages it is not permitted to place the object/subjects, which trouble the freedom of motions during maintenance or in repair work.

Distance between the unprotected bare current-carrying parts, arrange/located at height/altitude is less than 2.2 m along one side of passage, and by opposite wall either the equipment, which does not have or as the equipment, which does not have the unprotected current-carrying parts, must be with voltage to 500 V not less than 1 m, but with voltage 500 V it is above - it is not less than 1.5 m.

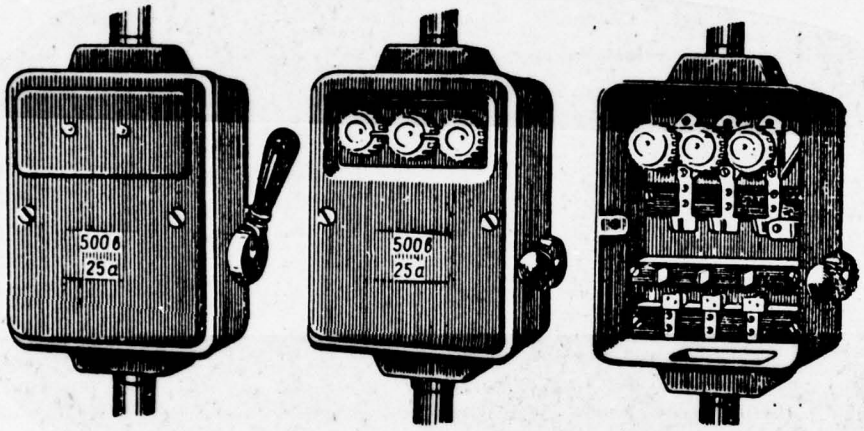


Fig. 44. Closed setting up of stopper safety device/fuses.

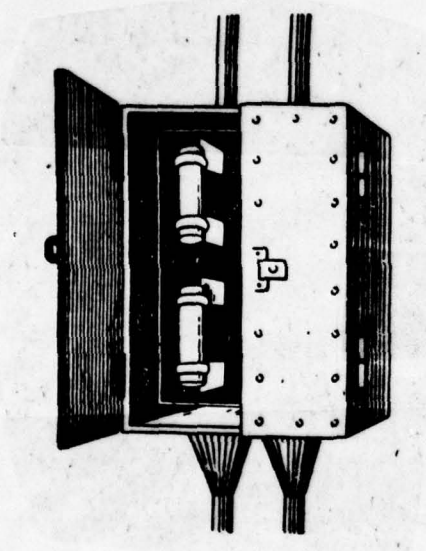


Fig. 45. Tubular safety device/fuses in cabinet.

The distance between the unprotected current-carrying parts, arrange/located at height/altitude is less than 2.2 m, from both sides of passage, is establish/installed following: with voltage to 500 V - not less than 1.5 m, with voltage it is above 500 V - is not less than 2 m.

The bare current-carrying parts, which are located on height/altitude are less than 2.2 m, compulsorily they are guarded. As enclosure/protections serve the meshes not less than 1.7 m in height, also, the size/dimensions of cells not more than 2 x 2 cm.

The doors, which lead for the distributing frame, are open/disclosed only outside. Smallest permissible width of doors 0.75 m, the smallest height/altitude of 1.9 m.

The end-type parts of the distributing frame on an entire height/altitude of floor level from doors or inputs must be completely protect/surrounded.

The distributing frames of equipment/device and the separate cabinets, which do not have admission from the back, must be carried out so that the connection of the feeding and exiting/waste cables and wires could be produced on the spot after the reinforcement of panel, ganged equipment/device or cabinet. The contact parts, serving

for the connection of cables, must be completely open-door and maintenance and be arrange/located within the limits of panel.

On the metal sheathings of power, lighting and control cables in open-door places, are attachhed the tags with the clear, easily read labels, which indicate brand, section and the number of cable according to the taken designation and the electrical circuit of this setting.

All terminals to which are connected control cables they are supplied with clear literal or digital designation. The tags, slipped over the wire ends, are made from insulating material.

5. Electric wirings.

The electric wirings of alternating and direct current by voltage to 1000 V are the totality of wires and cables from the pertaining to them attachments, which support and by shielding constructions.

There are different forms of electric wirings, namely: external, laid on the external walls of buildings and installations, under

mounting fixtures, on supports with the flight/spans between them to 25 m, and internal, carried out indoors.

By the construction of the wires, used for an electric wiring, we distinguish the shielded wires, which have above insulating layer the metal or other sheathing, which prevents insulation from mechanical damages, and the wire not protected, which do not have similar protective clothing.

Using the method of the execution of electrical wiring, they can be those who were opened, if wires run themselves on the surface of walls, ceiling and the farm/trusses of building, and those who were hidden, if wires run themselves in walls, sex/floors, the overlaps of buildings.

Page 104.

Tables 16. Permissible methods of the execution of electric wiring.

(1) Вид электропроводки	(2) Сухое помещение	(3) Влажное помещение	(4) Сырое и особо сырое помещение	(5) Жаркое помещение	(6) Пыльное помещение	(7) Помещение с химически активной средой	(8) Наружная проводка (вне помещения)	(9) Примечание
	(10) На роликах	(10) На роликах	(11) На роликах (для сырых мест)	(10) На роликах	—	—	—	
	(12) На изоляторах	(12) На изоляторах	(12) На изоляторах	(12) На изоляторах	(12) На изоляторах	(12) На изоляторах	(13) На изоляторах	

(14) Открытая а) Непосредственно по несгораемым конструкциям и поверхностям	(13) В трубах изоляционных с металлической оболочкой	—	—	—	(13) В трубах изоляционных с металлической оболочкой	—	—	(20) Во взрыво- и пожароопасных помещениях электропроводка выполняется согласно специальным правилам
	(15) В стальных трубах, коробах, лотках, гибких металлических рукавах	(16) В стальных трубах и коробах	(17) В стальных трубах	(18) В стальных трубах, коробах, лотках	(19) В стальных трубах, коробах	(17) В стальных трубах	—	
	(21) Кабелями, защищенными и специальными проводами	(21) Кабелями, защищенными и специальными проводами	(22) Кабелями	(23) Кабелями, защищенными проводами	(23) Кабелями, защищенными проводами	(22) Кабелями	—	
(24) б) Непосредственно по сгораемым конструкциям и поверхностям	(10) На роликах	(10) На роликах	—	—	—	—	—	
	(12) На изоляторах	(12) На изоляторах	—	—	—	—	—	
	(13) В трубах изоляционных с металлической оболочкой	—	—	—	—	—	—	
	(15) В стальных трубах, коробах, гибких металлических рукавах	(16) В стальных трубах и коробах	—	—	(16) В стальных трубах и коробах	—	—	
	(23) Кабелями, защищенными проводами	(23) Кабелями, защищенными проводами	—	—	(23) Кабелями, защищенными проводами	—	—	
(25) Скрытая	(26) В изоляционных трубах с металлической оболочкой	(27) В трубах изоляционных влагостойких	(27) В трубах изоляционных влагостойких	(26) В трубах изоляционных с металлической оболочкой	(26) В трубах изоляционных с металлической оболочкой	(28) В изоляционных трубах	(29) В стальных трубах специальными проводами	
(25) Скрытая	(30) В стальных трубах; глухих коробах; замкнутых каналах строительных конструкций зданий специальными проводами	(31) В стальных трубах	(31) В стальных трубах	(32) В стальных трубах и коробах специальными проводами	(31) В стальных трубах	—	—	

Key: (1). Form of electric wiring. (2). Dry location. (3). Humid location. (4). Damp/crude and especially damp/crude location. (5). Hot location. (6). Dusty location. (7). Location with chemically active medium. (8). External wiring (outdoors). (9). Note. (10). On rollers. (11). On rollers (for the damp/crude places). (12). On insulators. (13). In the tubes of insulating with metal sheathing. (14). Open a) is direct by the incombustible constructions and over surfaces. (15). In steel tubes, ducts, tray/chutes, the flexible metal hoses. (16). In steel tubes and ducts. (17). In steel tubes. (18). In steel tubes, ducts, tray/chutes. (19). In steel tubes, ducts. (20). In explosive-and flammable locations the electric wiring is made according to special rules. (21). By cables, shielded and by special wires. (22). By cables. (23). By cables, by the shielded wires.

Page 105.

Key: (24). b) is direct by the combustible constructions and over surfaces. (25). Hidden. (26). In insulating tubes with metal sheathing. (27). In tubes insulating moisture-proof. (28). In insulating tubes. (29). In steel tubes by special wires. (30). In steel tubes; dead/blind ducts; the closed channels of the structures of buildings by special wires. (31). In steel tubes. (32). In steel tubes and ducts by special wires.

Page 106.

Each electric wiring must correspond to its designation/purpose, operating conditions, to voltage, ambient effects, to the requirements for electrical safety and fire safety.

When selecting the type of electric wiring and method of the wiring and cables taking into account environmental conditions, it is possible to use data given in Table 16.

External electric wiring.

For an external electric wiring are applied unprotected isolated/insulated wires, which according to the degree of the danger of touch to their current-carrying parts are equated to bare wires and cables.

The wires of external electric wiring must be arrange/located in

such a way that they would be unavailable for the touch. The smallest permissible distances between wire and objects are shown in Table 17.

External surface wiring and the walls, which emerge on streets, is not allow/assumed.

Entrances one should make through tubes within walls in such a way that water could not be store/accumulated in them. Distance from the wires of addition to the earth/ground (with voltage to 1000 in) to the setting up of insulators on wall must be not less than 2.75 m and during the addition through the roof - it is not less than 2.5 m.

Table 17.

(1) Прокладка	(2) Расстояние от проводов наружной электропроводки в м						
	(3) над балконом	(4) под балконом	(5) до балкона	(6) над окном	(7) под окном	(8) до окна	(9) до земли
(10) Горизонтальная по стенам	2,5	1	—	0,5	1	—	—
(11) Вертикальная по стенам	—	—	1	—	—	0,75	2,75
(12) На опорах возле зданий	—	—	1,5	—	—	1,5	—
(13) Провода электропроводки, пересекающие пожарные проезды и пути транспорта	—	—	—	—	—	—	6
(14) То же вне проезжей части	—	—	—	—	—	—	3,5

Note. Above the porch of the roof of industrial building, the distance from wires to walls or supporting structures must be not less than 50 mm.

Key: (1). Separator. (2). Distance from the wires of external electric wiring in m. (3). above the balcony. (4). under balcony. (5). to balcony. (6). above the window. (7). under window. (8). to window. (9). to the earth/ground. (10). Horizontal on walls. (11). Vertical on walls. (12). On supports near buildings. (13). Wires of electric wiring, which intersect fire passages and the paths of transport. (14). The same outside transient part.

With the input unit of electric wires into electrical locations (with voltages to 1000 V and above 1000 V) and the mounting of wall entrance insulators must be constructed so that the moisture would not fall inside buildings.

Distance from the wires of addition to the earth/ground depends on voltage, and precisely: with voltage to 1 kV - 3.5 m; with voltage to 10 kV - 4.5 m and to 35 kV - 4.75 m.

Internal electric wiring.

Production indoors internal electric wiring can be carried out opened by unprotected insulated wires or the same wires, but placed in metal tubes, hose/pipes, ducts. Internal electric wiring can be also hidden, with the arrangement/permutation of wires in the closed channels (furrows) of the structures of building. A selection of the type of electric wiring and method of wiring must be substantiated by line voltage, by the conditions of operation, by ambient effect, by the requirements of electrical safety and fire safety and correspond to the indications of the "rules of equipment/device of electrical devices".

The insulation of wire and cables must correspond to nominal line voltage. With line voltage to 500 V the shielded and unprotected wires, must have insulation, designed to the nominal voltage of alternating current not below 500 V.

For the twisted twin conductors, run on rollers, there is allowed insulation to voltage 380 V, while for the cords, utilized for the connection of movable receivers (current), is allow/assumed insulation to voltage 220 V.

Neutral conductors must have insulation, equivalent of insulation of phases.

In production locations as working neutral conductors, is allow/assumed the use of metal pipes of open wiring, torses, housing of conductors, constructions of buildings, production constructions and mechanisms (for example, metallic farm/trusses, columns, crane runways and so forth). These current-conducting constructions it is allow/assumed to utilize as one of the working wires of line in grid/networks by voltage 36 V, for example for equipment/device of local illumination on machine tools, etc.

In all cases of using the current-conducting constructions of buildings, machines, conduit/manifolds and so forth, it is necessary

for the purpose of electrical safety to ensure the circuit continuity, necessary conductivity, visibility and strong joint with the electric welding of the separate cell/elements, utilized as wire.

Page 108.

Unprotected insulated wires it is allow/assumed to run without the supplementary insulation:

1) in steel tubes and ducts in normal, humid and dusty locations;

2) in tray/chutes in normal locations. In this case, the tray/chutes must be arrange/located at height/altitude not less than 2 m of the level of sex/floor or maintenance platform;

3) in the closed channels of the structures of buildings in the normal locations, which do not come into contact with humid, damp/crude and especially damp/crude locations, or not arrange/located in the sex/floors of the basement or sunk into the earth/ground locations.

In damp/crude and especially damp/crude locations for a separator and tubes, must be applied special wires with

moisture-proof insulation or in moisture-proof sheathing.

In the places where possibly the effect of gases or vapors, which destructively operate on insulation, must be applied the special wires, stable to the effect of the environment.

For the electric power supply of movable and movable electrical receivers, must be applied the patch cords and cables with copper vein/strands. All vein/strands of the indicated conductors (wires), including ground wire, must be in common/general/total sheathing.

Tubes and ducts must be installed so that in them could not be store/accumulated moisture from the condensation of the vapors, which were being contained in air.

In dry, not dusty locations and in the absence of gases, detrimentally operating on wire insulation, the connection of pipes, ducts of electric wiring it is realize/accomplished by collars without packing/seal. In the locations, which contain vapors and gases, and also in the places where to pipes of electric wiring they can fall oil, water, emulsion, connection of tubes and ducts must be carried out by the means of screwed sleeves also with the packing/seal of the places of union couplings and branchings. In the dusty locations the couplings of pipes and junctions must be consolidated.

In steel and other mechanically strong pipes, jackets, troughs the places of connections and branches of wires and cables should not undergo mechanical forces, and the insulation of their cores, current-conducting parts should be the same as the insulation of the entire places of these wires and cables.

Connections and the branchings of wires within ducts, tray/chutes, tubes and the metallic hoses, laid it is opened or hidden, they are not allow/assumed. All the connections and the branchings of wires must be made in coupling and branching ducts.

In places of the output of wires from tubes, hoses (hose/pipes), the ducts etc. wire must be shielded from damage. The tubes with electric wires, applied to separate apparatuses and instruments, must be introduced into the housings of apparatuses and instruments and tipped with insulating bushes or funnels. The actual connection of wires and cables to apparatuses and instruments and adjusting armature must be conducted by the means of caps or special terminal/grippers.

The connection of the wires of single-wire by section to 10 mm^2 and stranded from copper by section to 2.5 mm^2 is allow/assumed

without caps, but with soldering through and pressing.

Page 109.

The utilized for an electric wiring metal constructions, tubes, hose/pipes, tray/chutes, clamps so forth must be grounded and are shielded from corrosion.

In the steel and other mechanically durable tubes, the hose/pipes (hoses), tray/chutes, the closed channels of the structures of buildings is allow/assumed the combined wiring and cables:

1) of all circuits of one aggregate/unit;

2) the power and monitoring circuits of several machines, panels, panels, panels etc., connected by technological process;

3) the circuits, which feed complex illuminating lamp, or the circuits of several groups of one form of illumination;

4) lighting branch circuits to 36 V with branch circuit to 500 V under the condition of the conclusion of pressure wires 36 V into separate insulating tube.

In one tube, duct or tray/chute, the combined separator of the mutually reserved circuits, and also the circuits of working and emergency light is forbidden.

The wires and the cables, run in ducts and tray/chutes, must have designation.

For the electric power supply of movable and movable electrical receivers, one should apply patch cords and the cables with copper vein/strands, specially intended for this purpose, taking into account possible mechanical effects.

When, in the places, the wiring, oils and emulsion is present, one should apply wires with oil-resistant insulation or of the wires, which have protection from their effect.

Distance from openly laid unprotected insulated wires to bearing surface should be not less than 1 cm.

Insulating tubes with metal sheathing, the shielded wires, cables and the flexible metal hoses must be attached on the bearing surfaces of the tube through 0.8-1 m; wire, cables, metallic

hose/pipes - through 0.5-0.7 m.

Openly laid tubes are secured on the horizontal and vertical sections through 2.5-4 m depending on the diameter of tube.

During the intersection of the unprotected wires at a distance from each other less established/installed 35-100 mm (on rollers) or during the intersection of wires with section from 35 to 120 mm² at a distance of less 70-150 mm (on insulators) with the same section of wire to wires of one of the secants must be put on and attached the cuts of insulated tube with a length of 10 mm; during the intersection of the unprotected wires with the shielded wires the distance between them must be not less than 50 mm.

Page 110.

Distance with intersection of wires with conduit/manifolds with flammable liquids must be not less than 100 mm, with parallel laying the distance from wires and cables to conduit/manifolds must be not less than 100 mm and to conduit/manifold with flammable liquids - it is not less than 200 mm.

When, indoor, the bare open wiring is present, must be provided for in the case of the necessity to produce disconnection/cutoff on

all phases of this section. In electrical locations there is allowed bare wiring with any voltage, but with necessary equipment/device of the proper enclosure/protections, passages, signaling, etc.

The bare and bare shielded wires (in cases) must be removed from each other and from the walls of buildings and grounded constructions according to the indications of Table 18.

Conductors.

The advisable modernization of electric wiring, realize/accomplished by bare wires, are the conductors, intended for channeling of electric power, by which is understood the equipment/device, which consists of bare conductors with all relating to them insulators.

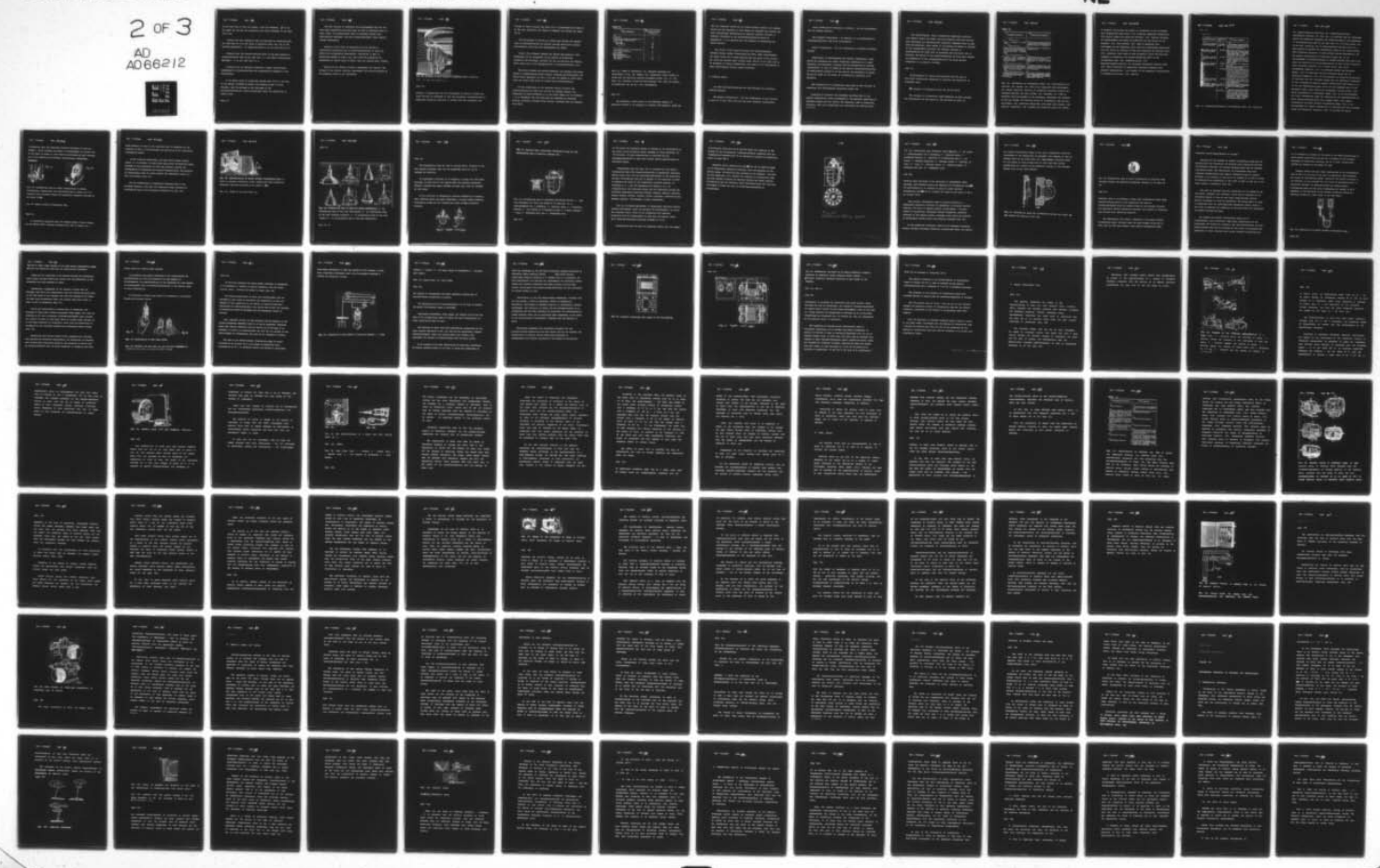
They are made in the open version with the conductors, not shielded from touch; in the shielded version, not exposed and incidence/impingement of foreign objects and in closed version - in the dust-proof or shielded from spatters duct.

The smallest sections of the wires of the open conductors must

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be not less than 2.5 mm² for copper, 4 mm² for aluminum, ⌀ 3.5 mm for steel and 120 mm² for tape/strip with their thickness is not less than 3 mm.

Indoors the open conductors must be installed at height/altitude not less than 3.5 m of the level of sex/floor (Fig. 46), and in the shielded performance - at height/altitude it is not less than 2.5 m.

Distance from the current-carrying parts of the open busbars to conduit/manifolds must be not less than 1 m, and before technological equipment - it is not less than 1.5 m.

Distance from the shielded conductors, closed, dust-proofed, splashproof of conduit/manifolds and technological equipment is not standardized.

On an entire route of conductors through each 10-15 m, and also in the places, attended by people (the landing fields of crane drivers), must be arranged on the tap/crane of the enclosure/protections, which prevent/warn about the possibility of random touch.

The bare wirings of conductors are allow/assumed only for the main lines branchings from which must be made by insulated wires in steel tubes. To arrange/locate their is necessary higher than technological equipment, and also conduit/manifolds, which require regular maintenance.

Directly of the place of branching from the feeding or distributive conductors must be establish/installed in open-door places the corresponding apparatuses. Last/latter it must be protect/surrounded in such a way, that would be eliminated the possibility of random touch to parts, that are located under voltage.

Wirings of the control circuits, measurement and control. The voltage in the control circuits, measurement and control/checking by the operating rules is not calibrated.

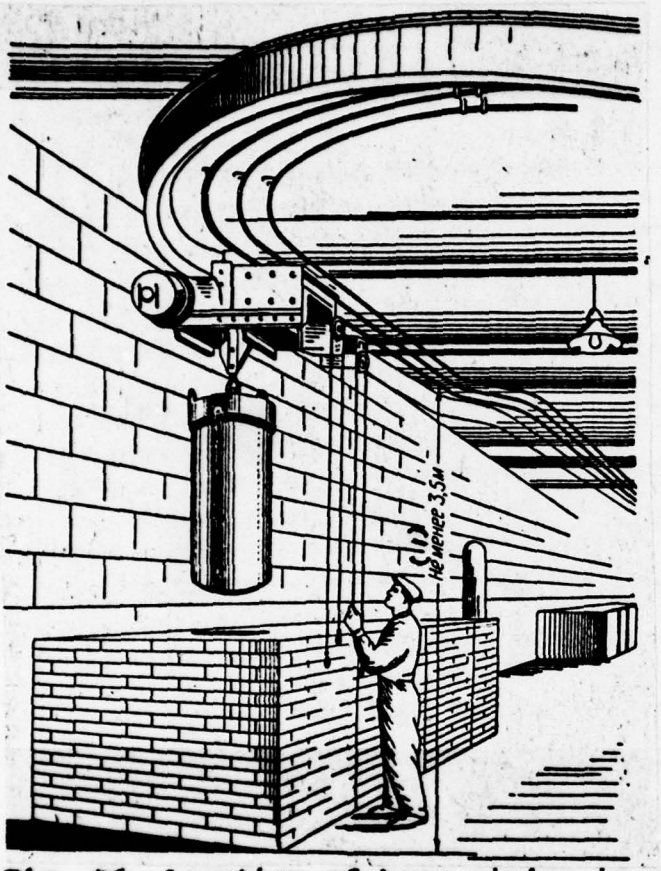


Fig. 46. Location of bare wiring in explosion proof locations.

Key: (1) Not less than 3.5 m.

Page 112.

However, if apparatuses and the instruments of control circuits are found directly on equipment or near the equipment, arrange/located in especially dangerous locations or working with wet processes, the

voltage of these circuits one ought not to allow/assume more than 36 V. The wire insulation and cables is designed for voltage not below 500 V.

The fulfillment of wiring as a whole must satisfy the general rules of equipment/device of electric wirings taking into account environmental conditions and requirements for safety.

Circuit for different objects one should make separate. This requirement is not propagated on the circuit of protection, automation and blockings, provided for for two and more the objects, which relate and to one aggregate/unit, to block/module/unit, etc.

The control cables and control/checking, run together with power cables in common/general/total tunnels, channels and shaft/mines, one should place separately in such a way that the damage of power cable could not cause cable fault of control and control/checking.

All the connections of the separate control circuits and control/checking are made with the aid of terminal series; the connection of wires soldering or in any other manner not on terminals - it is forbidden. The wire ends must be connected up terminals solidly, providing reliable fixed contact. Terminals must be shielded from touch.

Table 18.

(1) Виды токопроводов	(2) Наименьшие расстояния (в свету) в мм
(3) Открытые	50
(4) Токопроводы, состоящие из проводов при расстояниях между точками крепления:	
(5) до 2 м	50
(6) от 2 до 4 м	100
. 4 . 6 .	150
(7) . 6 м	200
Защищенные, закрытые и пыленепроницаемые	
(8) по поверхности изоляции	20
(9) по воздуху	12
(10) Брызгозащищенные:	
(8) по поверхности изоляции	70
(9) по воздуху	50

Key: (1). Forms of conductors. (2). Smallest distances (in world/light) in mm. (3). Opened. (4). Conductors, which consist of wires with the distances between attachment points. (5). to. (6). from. (7). Shielded, closed and dust-proofed. (8). over the surface of insulation. (9) by air. (10). Splashproof.

Page 113.

The terminals, which relate to the different objects of electrical device it is necessary to isolate into separate, those who

were not connected friend and by friend terminal series. All terminal series and the connected to them cables are supplied with durable and clear conventional designations of separate circuits (letters or numerals) according to the established/installed system of designation - it is separate for the circuits of alternating and direct current.

The wiring of the control circuits and control/checking, terminal series, safety device/fuses and their other cell/elements one should drive out to safe distance from the parts of the setting up, which are located under voltage above 1000 V. At the same time it is necessary to ensure accessibility and safety of the maintenance of these cell/elements without stress relieving.

6. Lighting plants.

By their designation/purpose are distinguished the following lighting systems.

The general illumination - for the illumination of any location or part of it both from identical and with different illumination.

Local illumination stationary or movable - for the illumination only of working surfaces.

The combined illumination - as totality it is simultaneous of common/general/total and local illumination.

Repair illumination - for the illumination of separate building grounds.

furthermore, is distinguished the working illumination, which serves for providing the proper visibility conditions in a normal operation, and emergency, utilized with the malfunction of working illumination, if this is caused by the special feature/peculiarities of technological process or by the need of the evacuation of people during the onset of the danger of traumatism in connection with emergency.

The construction of illuminating lamps must be most rational in connection with environmental conditions (Table 19).

Armatures in explosive and flammable locations must be the special construction, which corresponds to the specific conditions of explosion hazard and fire hazard. The armatures, used in damp/crude locations, must have receptacles from insulating and moisture-proof materials.

The reinforcements, used in especially damp/crude locations, with caustic vapors and gases, and also outdoors, must have housing from insulating and moisture-proof materials themselves must be made from the materials, which oppose to the effects of medium or shielded by the corresponding coatings; the internal cavities of reinforcements and tubes must be protected from the direct hit of moisture. The method of the input/introduction of wires must exclude the possibility of the closing/shorting of the wires between themselves or to metallic fittings.

Page 114.

Reinforcements for dusty locations must have the open or dust-proof construction depending on character and quantities of isolatable dust.

The voltage of illumination must not exceed 220 V.

The voltages of illuminating lamps depending on their purpose, the construction and the places of use are shown in Table 20.

Table 19.

(1) Исполнение светильников	(2) Характеристика помещения
(3) Открытые	
(4) Лампа не отделена от внешней среды	(5) Нормальные помещения. Большинство производственных помещений без повышенной влажности и запыленности
(6) Защищенные	
(7) Лампа отделена от внешней среды оболочкой, не препятствующей обмену воздухом между внутренней полостью светильника и внешней средой	(8) Помещения сырые, с небольшим содержанием пыли
(9) Влагозащищенные	
(10) Корпус и патрон противостоят воздействию влаги и обеспечивают сохранность изоляции введенных в светильник проводов	(11) Помещения особо сырые, с едкими парами и газами и вне помещений (12) Внутренние полости арматур и ламп предохранены от прямого попадания влаги
(13) Пыленепроницаемые	
(14) Лампа отделена от внешней среды оболочкой, не допускающей проникновения в полость расположения лампы и патрона тонкой пыли	(15) Помещения, содержащие пыль высокой дисперсности, разрушительно действующую на изоляцию и токоведущие части светильника
(16) Взрывозащищенные	
(17) Взрывонепроницаемость; повышенная надежность против взрыва	(18) В условиях взрывоопасных помещений и наружных установок—соответственно действующей классификации взрывоопасных помещений
(19) Специальное	

Key: (1). Performance of illuminating lamps. (2). Characteristic of location. (3). Opened. (4). Tube is not separated from environment. (5). Normal locations. Majority of production locations without the increased humidity and dust content. (6). Shielded. (7). Tube is separated from environment by the sheathing, preventing the exchange of the air between the internal cavity of illuminating lamp and the environment. (8). Locations damp/crude, with small dust content. (9). Moisture -protected. (10). Housing and receptacle resist the effect

of moisture and provide the safety of insulation of the introduced into illuminating lamp wires. (11). Locations especially damp/crude, with caustic vapors and gases and outdoors. (12). Internal cavities of reinforcements and tubes are protected from the direct hit of moisture. (13). Dust-proofed. (14). Tube is separated from environment by the sheathing, which does not allow/assume penetration into the cavity of location of tube and receptacle of fine/thin dust. (15). Locations, dust-laden of high dispersity, which destructively operates on insulation and current-conducting parts of the illuminating lamp. (16). Explosion-proof. (17). Explosive-impenetrability; the increased reliability against blast. (18). Under conditions of dangerously explosive locations and external installations - with respect to the operating classification of explosive locations. (19). Special.

Page 115.

Table 20.

(1) Назначение светильника	(2) Напряжение в	(3) Условия применения
(4) 1. Общее освещение лампами накаливания	127—220 (5) (фиг. 47)	(6) В помещениях с повышенной опасностью и особо опасных высота подвеса светильника должна быть не менее 2,5 м от уровня пола
2. Общее освещение лампами накаливания	127—220	(7) В тех же помещениях, но при высоте менее 2,5 м должны применяться светильники конструкций, исключающих доступ к лампам без специальных приспособлений
(8) 3. Общее освещение люминесцентными лампами	127—220	(9) Допускается устанавливать на высоте менее 2,5 м при условии недоступности их токоведущих частей (контактов, стартера) для случайного прикосновения
4. Местное освещение лампами накаливания	127—220	(11) В помещениях без повышенной опасности
	36	(12) В помещениях с повышенной опасностью и в особо опасных
	127—220	(13) Допускается как исключение в помещениях с повышенной опасностью (но не особо опасных) для светильников специальной конструкции (см. выше п. 2), а также для светильников, являющихся составной частью аварийного освещения, питающегося от независимого источника тока
5. Местное освещение люминесцентными лампами	127—220	(15) Допускается для местного освещения при условии недоступности их токоведущих частей для случайного прикосновения
6. Ремонтное освещение ручными переносными светильниками	36 (5) (фиг. 48)	(17) Допускается для ремонтного освещения в помещениях с повышенной опасностью и особо опасных
	12 (5) (фиг. 49)	(18) Допускается для ремонтного освещения при наличии особо неблагоприятных условий работы, увеличивающих опасность поражения током из-за прикосновения работающего к заземленным и хорошо проводящим поверхностям зданий, конструкций, механизмов, оборудования

Key: (1). Designation/purpose of illuminating lamp. (2). Voltage V.

(3). Application/use conditions. (4). Common/general/total incandescent lighting. (5). Fig. (6). In locations with the increased danger and especially dangerous the height/altitude of the suspension of illuminating lamp must be not less than 2.5 m of floor level. (7). In the same locations, but at height/altitude are less than 2.5 m there should be applied the illuminating lamps of the constructions, which eliminate admission to tubes without special attachments. (8). The general illumination by fluorescent lamps. (9). It is allow/assumed to establish/install in height/altitude less than 2.5 m under the condition of the inaccessibility of their current-carrying parts (contacts, starter) for a random touch. (10). Local incandescent lighting. (11). In locations without the increased danger. (12). In locations with the increased danger and in especially dangerous. (13). Is allow/assumed as exception/elimination in locations with the increased danger (but not especially dangerous) for the illuminating lamps of special construction (see above p. 2), or for the illuminating lamps, which are the component part of the emergency light, which feeds from independent current source. (14). Local illumination by fluorescent lamps. (15). It is allow/assumed for local illumination under the condition of the inaccessibility of their current-carrying parts for a random touch. (16). Repair illumination by manual movable illuminating lamps. (17). It is allow/assumed for repair illumination in locations with the increased danger and especially dangerous. (18). Is allowed for repair

illumination when the especially adverse conditions of work are present,, which increase the danger of damage/defeat by current due to the touch of worker to that which was grounded and well carrying out to the surfaces of buildings, constructions, mechanisms, equipment.



Fig. 47.



Fig. 48.

Fig. 47. Illuminating lamp of normal construction of general illumination, suspend/hung from height/altitude is below 2.5 m in locations with increased danger and especially dangerous (voltage is not above 36 V).

Fig. 48. Manual movable illuminating lamp.

In production locations with the average degree of dust content, can be applied usual lighting fixtures (Fig. 50). If indoor is a

large quantity of dust or the isolating dust is dangerous in the relation to fire, is allow/assumed the setting up of the dust-proof illuminating lamps.

In the locations damp/crude, and also which contain caustic vapors, it is necessary to apply dust-water-proof illuminating lamps, shielded of the penetration of dust and moisture, calling the decomposition of insulation and current-carrying parts. The material of reinforcement must be stable against the destructive effect of dust and moisture (Fig. 51).

For the illumination of production locations with by the increased humidity, fine dust and industrial gases intended the illuminating lamp of the increased reliability PN (Fig. 52).

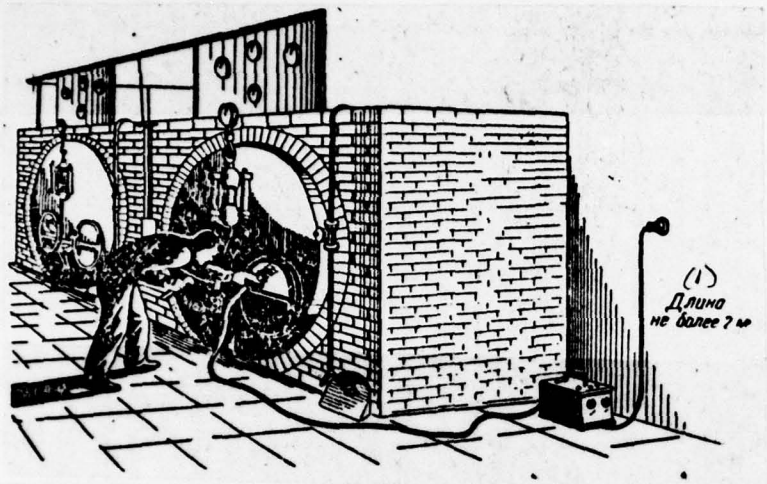


Fig. 49. Application/use of manual movable illuminating lamps in works in metallic reservoirs, pits, tunnels and other especially dangerous locations (voltage is not above 12 V).

Key: (1). Length is not more than 2 m.

Page 117.

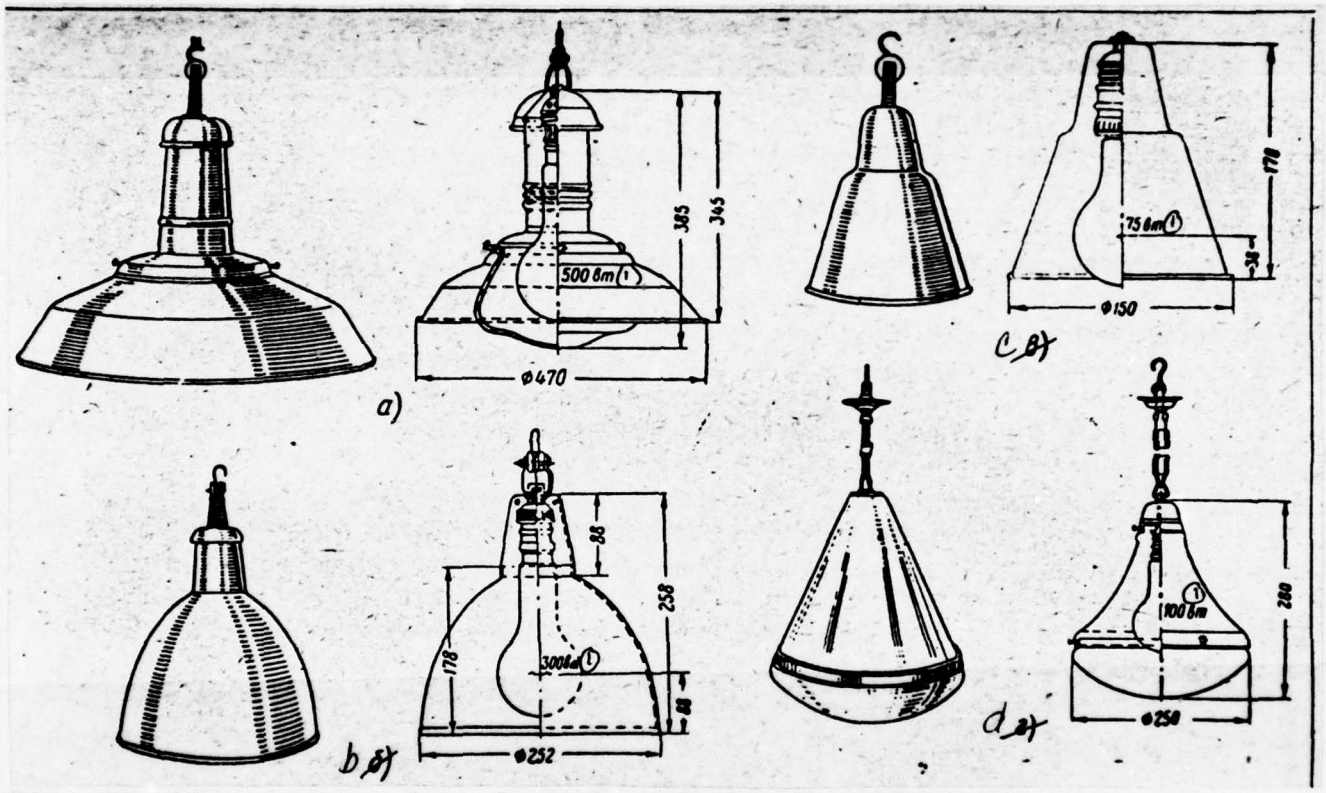


Fig. 50. Illuminating lamp in open and closed performance. a - an illuminating lamp of the type "Universal", b - an illuminating lamp of the type "intense radiater", c - an illuminating lamp of the type "Alpha"; d - an illuminating lamp of the type "Lyutsetta".

Key: (1). W.

Page 118.

The illuminating lamp PN, used to voltage 300 W, consists of the cast metallic housing, bell jar and suppressor grid; it can be equipped by reflector.

In inflammable locations it is necessary to apply the dust-proof fittings; in this case in the places where are possible mechanical effects, illuminating lamps, besides the bell jars, must be shielded by wire gauze.

In the locations of dangerously explosive depending on category, their lighting plants are made differently. Are most common pneumatic illuminating lamps and the illuminating lamps of high mechanical strength.

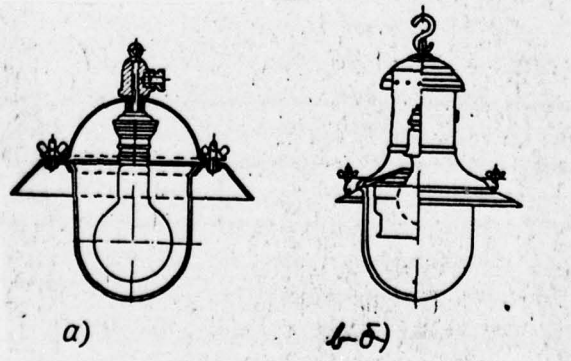


Fig 51. Caption next page.

Fig. 51. Metallic dust- watertight illuminating lamp (a) and illuminating lamp of exterior lighting (b).

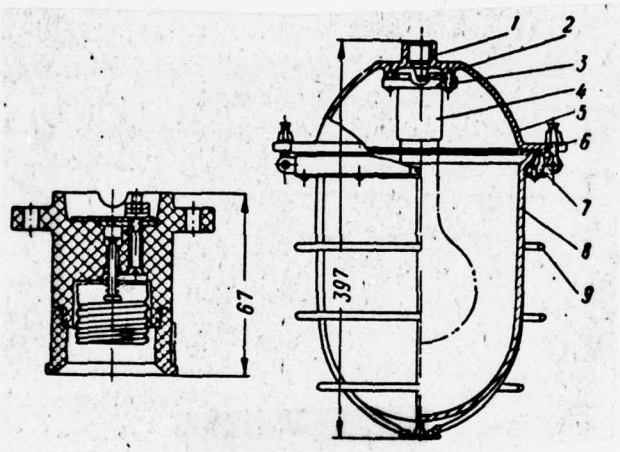


Fig. 52. Illuminating lamp of increased reliability PN-300. 1 - tube for attachment 3/4 "with the thread of 14 turns per 1", 2 - screw/propeller for a grounding, 3 - retainer screw, 4 - receptacle special, 5 - the housing of illuminating lamp, 6 - rubber packing, 7 - ring, 8 - shielding bell jar, 9 - suppressor grid.

In the latter the explosion hazard is removed by its localization in the space of the protective glass, designed to large pressures (to 10-30 kg/cm^2). In some constructions is provided for the disconnection/cutoff of tube from network during removal/taking of protective glass.

Illuminating lamp VZG (Fig. 53) is intended for the general illumination where the formation/education of dangerously explosive medium occurs only with the disturbance/breakdown of the production process. Illuminating lamp VZG is applied in the locations in which is possible the onset of the dangerously explosive mediums, in reference to 1, 2 and 3rd categories and groups A, B, G on combustibility. The indicated groups and the categories include the following dangerously explosive mediums: methane, ammonia, gasoline, butane, ethane, alcohol, toluene, xylene, ethylene, illuminating gas, benzene, pentane, acetaldehyde, hexane, ether/ester.

With the incidence/impingement of dangerously explosive mediums inside reinforcement under the cap/hood of reinforcement, can occur the localized blast, which is not propagated into location. Protective hood of reinforcement is made from the special glass, which maintain/withstands explosion pressure to 10 at.

Illuminating lamp VZG does not guarantee safety with the damage

of protective glass and can be applied under the condition of the absence of the technological treatment/working, connected with the fragmentation fragmentation of raw material or product of production. Power of tubes 200 W.

Explosion proof illuminating lamp [illegible]-100 can be applied almost in all dangerously explosive locations, with the exception of the special cases. Illuminating lamp consists of two housings - the bell jar and suppressor grid. Between the housings of illuminating lamp, and also between cap/hood and internal housing are rubber packing. Illuminating lamp has blocking, which disconnect/turns off tube with the damage of glass and with the disturbance/breakdown of airtightness.

Fig 53. Caption next page.

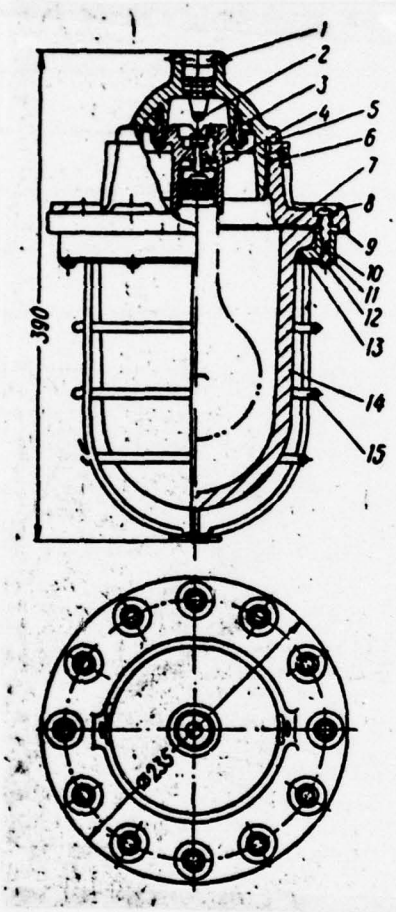


Fig. 53.
[caption on following page]

Fig. 53. Illuminating lamp (explosion proof VZG-200.) 1 - set screw, 2 - screw/propeller for a grounding, 3 - retainer screw, 4 - receptacle special; 5 - cap/cover of illuminating lamp, 6 - set screw, 7 - aluminum separator, 8 - retainer screw, 9 - housing, 10 - ring, 11 - ring, 12 - retainer screw, 13 - asbestos gasket, 14 - shielding bell jar, 15 - suppressor grid.

Page 120.

Blocking works according to the principle of overpressure under cap/hood, and therefore during the operation of illuminating lamp RV-100 periodically it is required to pump air under cap/hood. Illuminating lamp RV-100 is intended for tubes by the power of 100 W by voltage 120 V.

When similar illuminating lamps to utilize directly in dangerously explosive locations is impossible, is arranged exterior lighting. For this, is applied special reinforcement - "oblique lights" or projectors, adjustable outside dangerously explosive locations in the special niches, arranged within walls and shielded by sufficiently durable glass with metallic gratings (Fig. 54).

In the production locations, which do not represent explosion hazard, besides stationary electrical illuminating lamps, are applied

the movable illuminating lamps of the local illumination which for convenience in the observation of procedure (for example, in work on machine tool) can be moved (Fig. 55). Requirements indicated above for the safety of lamp sockets have in this case even greater significance as a result of the immediate vicinity of the grounded machine tool or any other machine.

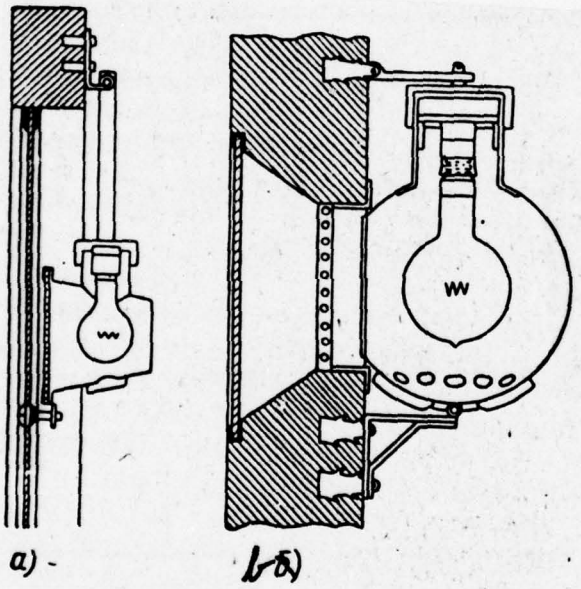


Fig. 54. Illuminating lamps for illumination through the window (a) and through the opening in wall (b).



Fig. 55. Illuminating lamp of local illumination in locations with increased danger and especially dangerous (voltage is not above 36 V).

Page 121.

Therefore here it is possible to apply only illuminating lamps whose current-carrying parts of the receptacle and base are protect/surrounded from the random touchs by the reliably fastened and especially durable protective coatings. The housing of receptacle must be made from insulating material.

The requirements for safety, presented to the manual movable illuminating lamps, utilized under the most diverse conditions of work, must be even more raised, since manual illuminating lamps

frequently cause damage/defeats by current.

Housings and the handles of movable illuminating lamps must be manufactured from flameproof and moisture-proof insulating material of sufficient strength. All current-carrying parts must be shielded from random touch. The construction of illuminating lamp must withstand incidence/drop and impacts. Receptacle must be solidly fastened in the housing of tube and it is drowned so so that it would be eliminated the possibility of the touch to base of lamp and to the screw socket of receptacle (Fig. 56).

Tube must be shielded from the possibility of its damage by the wire gauze, equipped with reflector. Grids must be fastened on the insulating handle of tube so that their removal/taking without special attachment it would be impossible. The wiring point of wires to receptacle must not experience/test mechanical forces, since in this case is possible the weakening of contacts within the receptacle of movable illuminating lamp.

Key sockets for movable illuminating lamps are not allow/assumed, since key/wrench complicates construction and can render/show the reason for accidents. The input/introduction of wires inside movable tube must be arranged so that would be eliminated the possibility of their fracture even during careless access/rotation.

It is necessary to arrange in the place of the input/introduction of wires special protection with the aid of sleeves or the flexible sheathings of sufficient strength, put on to wire. Collars must reliably be secured on the handle of tube.

However, during the most ideal construction of the illuminating lamp of wire in the case of the wear of insulation, they represent the source of considerable danger. Therefore the correct solution to the question, as are provided for the "rules of equipment/device of electrical devices", is application/use for manual movable illuminating lamps and the local illumination of voltage 12-36 V depending on the character of the ambient production medium and operating conditions, about which it was said above.

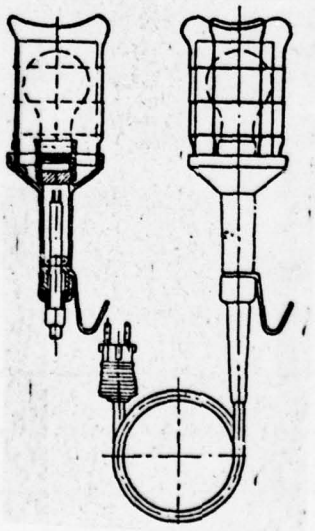


Fig. 56. Construction of manual movable illuminating lamp.

The use of usual tubes instead of the safe manual illuminating lamps, and also the defective tubes must be categorically forbidden.

Tubes must be connected to the network through the receptacles, which ensure reliable electrical contact and the possibility of the convenient and safe exchange of tubes.

Receptacles, independent of the voltage to which they are designed, must have this construction that the current-carrying parts of the tube would be not exposed, but with the screwing in of tubes, its base could render/show under line voltage only after touch to base it will be impossible (Fig. 57).

During the unsatisfactory construction of receptacle, the exchange of tubes under voltage represents large danger. So, with the screwing in of tube is possible incidence/impingement under voltage as a result of touch to tube base, which is located under voltage, or to the metal sheathing of receptacle, which with the malfunction of receptacle or its low-grade charging can render/show under voltage (Fig. 58).

Receptacles with normal thread (E-27), equipped with switches, must satisfy the following requirements: the knob/sticks of switches must be made from insulating material; the axle/axis of switch must be isolate/insulated from the metal sheathing of receptacle and from

parts, which are located under voltage.

In production and public buildings is not allow/assumed the application/use of cord and adjusters for lamp pendant of reinforcements. The application/use of the adjusters for lamp pendant is allow/assumed only as exception/elimination in the special cases of local illumination.

In three-wire networks lamp socket is connected to the network through the two-pole switch.

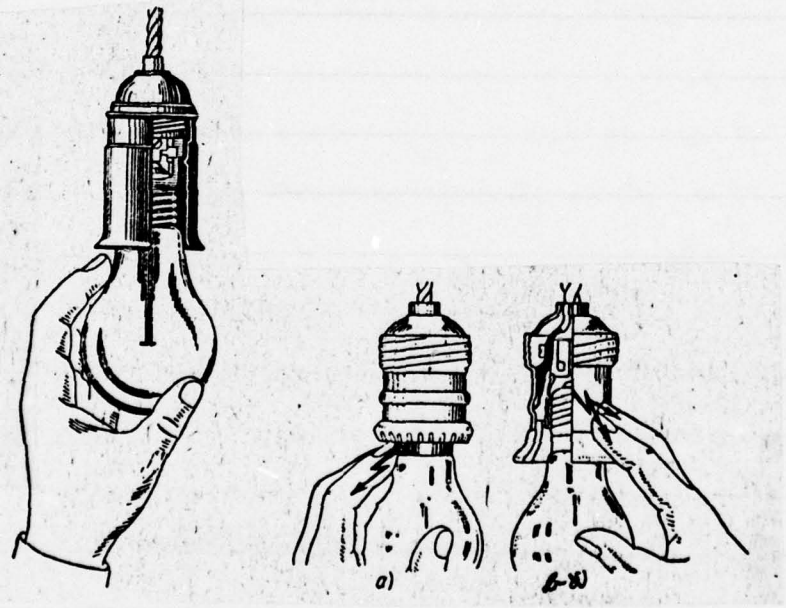


Fig. 57. Construction of safe lamp socket.

Fig. 58. Touching the lamp base (a) and the metal sheathing of receptacle (b), that are located under voltage.

Page 123.

In four-wire networks the screw socket (cutting) of receptacle it is necessary to connect up neutral conductor, and the second contact (butt) - through the switch to phase (Fig. 59).

The input/introductions of wires into reinforcement must be arranged so that would be eliminated the possibility of wear and damages of wire insulation in the points of input/introduction, connections of conduit/manifold, into pivots and so that the contacts of receptacles would be unloaded from the mechanical forces of voltage.

With imperfect surface of tube envelope and the presence of the current-conducting deposits touch to it can be dangerous. Therefore along with correct selection and the setting up of fittings it is necessary to follow its purity/finish not only for the purpose of the effectiveness of illumination, but also in the interests of safety.

The feed of the movable manual illuminating lamps of repair illumination by voltage 12-36 V and lamps of stationary local illumination on 36 v is conducted either from movable or stationary

step-downs transformer or from the network of low voltage. In this case, step-downs transformer must have the separate windings of primary and secondary voltage.

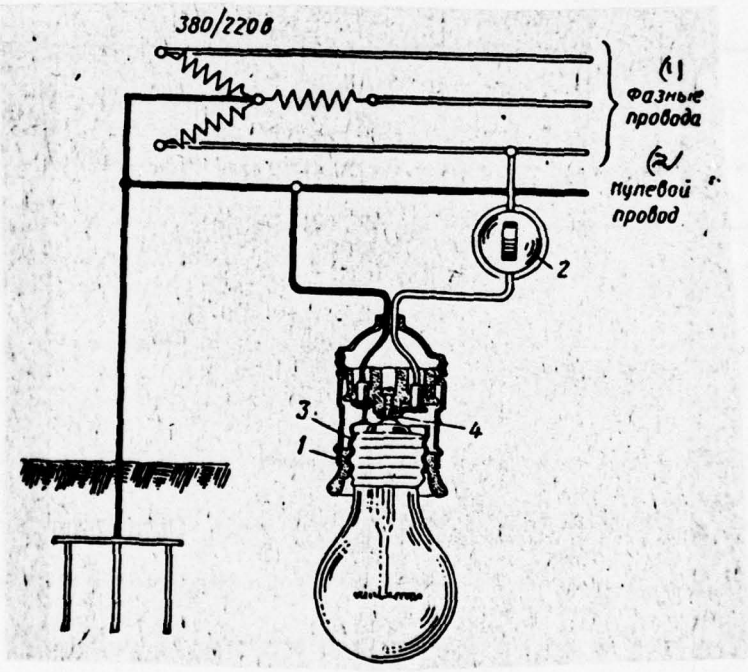


Fig. 59. Connection of lamp socket to four-wire network. 1 - lamp

socket, 2 - switch, 3 - the screw thread of receptacle, 4 - internal part (butt).

Key: (1). phase leads. (2). Zero leads.

Page 124.

The housing of transformers and their secondary winding must be grounded before connection to network.

The application/use of autotransformers for the feed of movable and manual illuminating lamps is forbidden.

Step-downs transformer, which ensure low voltage 12-36 V for the feed of the illuminating lamps of repair and local illumination, by their construction must be safe.

The obtained in their time wide distribution transformers of the type, similar indicated in Fig. 60, with by the unprotected, exposed terminal/grippers, which are located under line voltage, were repeatedly the sources of electrotraumas with the fatal result.

As an example of the safe construction of step-down transformer for manual portable lamps to 12 V Fig. 61 shows the transformer on

220/12 V, developed by the All-Union scientific research institute of industrial safety measures VTsSPS [All-Union Central Trade-Union Council] (authors A. P. Veselov and V. I. Korolkov). In this construction are realized all requirements for electrical safety taking into account protection from short circuit, from no-load losses, the greatest cost-effectiveness/efficiency and the provisions for normal stress on tube.

Construction is rod type single-phase transformer, included into the iron jacket, closed by cap/cover. Jacket is equipped by knob/stick, which makes it possible easy and to conveniently transfer transformer. The cap/cover of jacket and the arranged/located on it receptacles and the pins, entering the cap/cover, are consolidated by rubber packing; thus, can be attributed this transformer to the class of the closed movable transformers, shielded from the spatters of water.

Transformer possesses high dielectric strength; all the current-carrying connections are made inside and are not exposed. The construction of tripolar bullet connection guarantees an indispensable and constant grounding of the jacket of transformer.

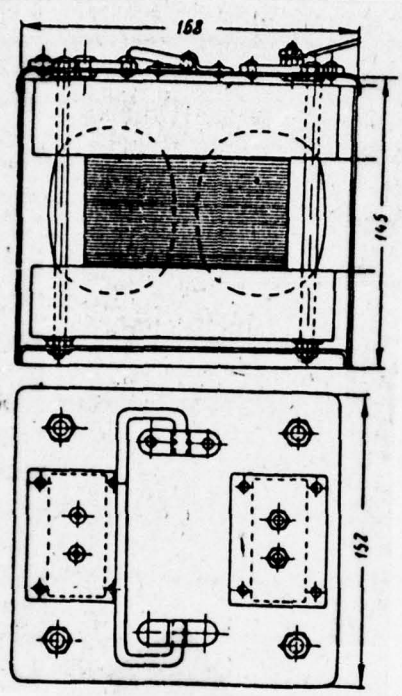


Fig. 60. Portable transformer with power of 100 volt-amperes.

Page 125.

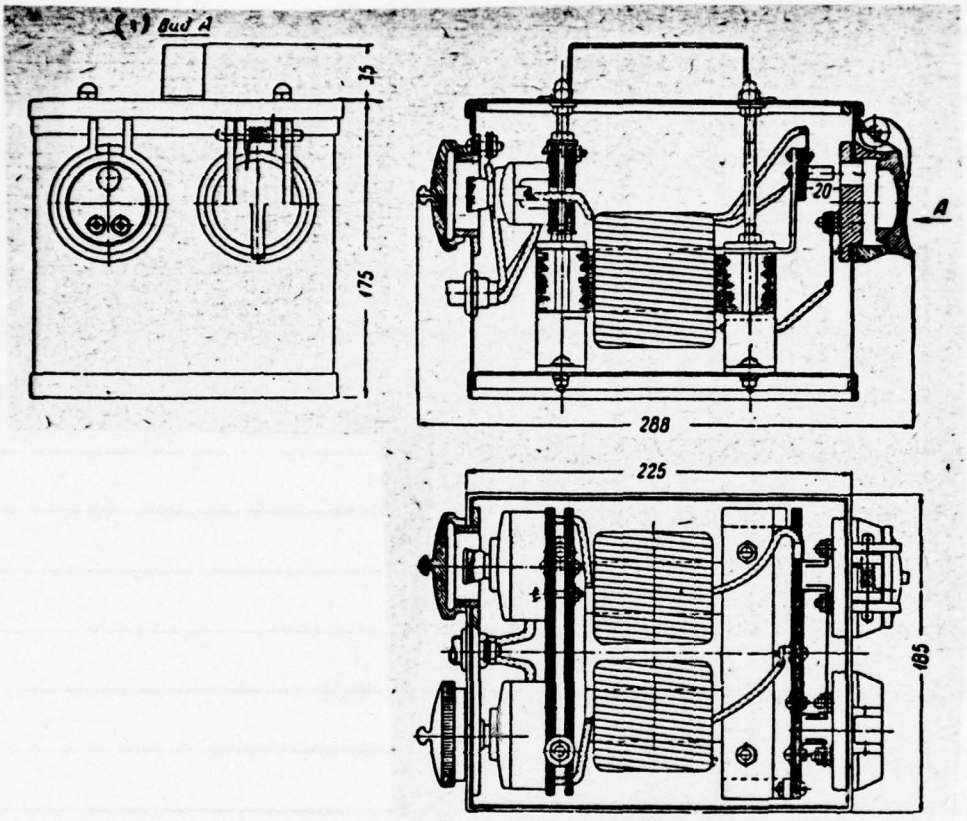


Fig 61. Caption next page.

Fig. 61. Transformer, developed by All-Union scientific research institute of industrial safety measures VTsSPS (VNIIOT [All-Union Scientific Research Institute of Work Safety of the VTsSPS]).

Key: (1). Form A.

Page 126.

Furthermore, is provided for protection from short circuit, which provides the life of transformer. The automatic disconnection/cutoff of running-light current is also known achievement, since in the case of a large quantity of transformers in settings up in no-load work transformers are decreased cos φ of setting up, what is, undoubtedly by the negative factor of operation.

The connection of movable manual illuminating lamps to step-downs transformer and of movable step-downs transformer to network 127-220-380 V must be realize/accomplished with the aid of flexible (hose) wires. In this case, the wires must be equipped with respect to their designation/purpose bullet connections which, being are intended for different voltages, structurally they must differ from each other, so that the plugs to 12 and 36 V could not be included in receptacles 110 and 220 V, but plug 12 V, furthermore I

could not be included in receptacle 36 V.

The metallic housings of the reinforcements of illuminating lamps to voltage 127-220 V must be equipped by the special screw/propellers with a diameter of 4 mm for a shielding grounding.

The grounding of the housings of illuminating lamps with grounded neutral of network must be realize/accomplished as follows:

with the surface work of wires - with the aid of the pigtails between the grounding contact of illuminating lamp and the neutral conductor, adjustable on the nearest to illuminating lamp fixed support;

with the separator of shielded insulated wires, cables or wires in the steel tubes, introduced into the housing of illuminating lamp - through the special part with the aid of the connection of the housing of illuminating lamp with neutral conductor it is direct into illuminating lamps.

7. Manual electrified tool.

Page 127.

The question concerning the safety of the application/use of hand tool with electric drive (electric drill, electric nut drivers, electric bolt drivers, polishing and polishing machines, electric soldering irons, threadcutters, vibrators) has large value in connection with the wide use of an electric drive under the most diverse conditions of production (Fig. 62).

The increased danger with the use of this instrument is caused by prolonged contact with power tool with a good contact between the metallic housing of instrument and hands and the body of worker; the determination near the metallic,well grounded object/subjects; by work in damp/crude locations or on the open air.

Obviously, most reliable safety method from damage/defeat by current is the application/use of a current of allowable stresses, connected with the setting up of special step-down transformers for each tool or for the group of tools.

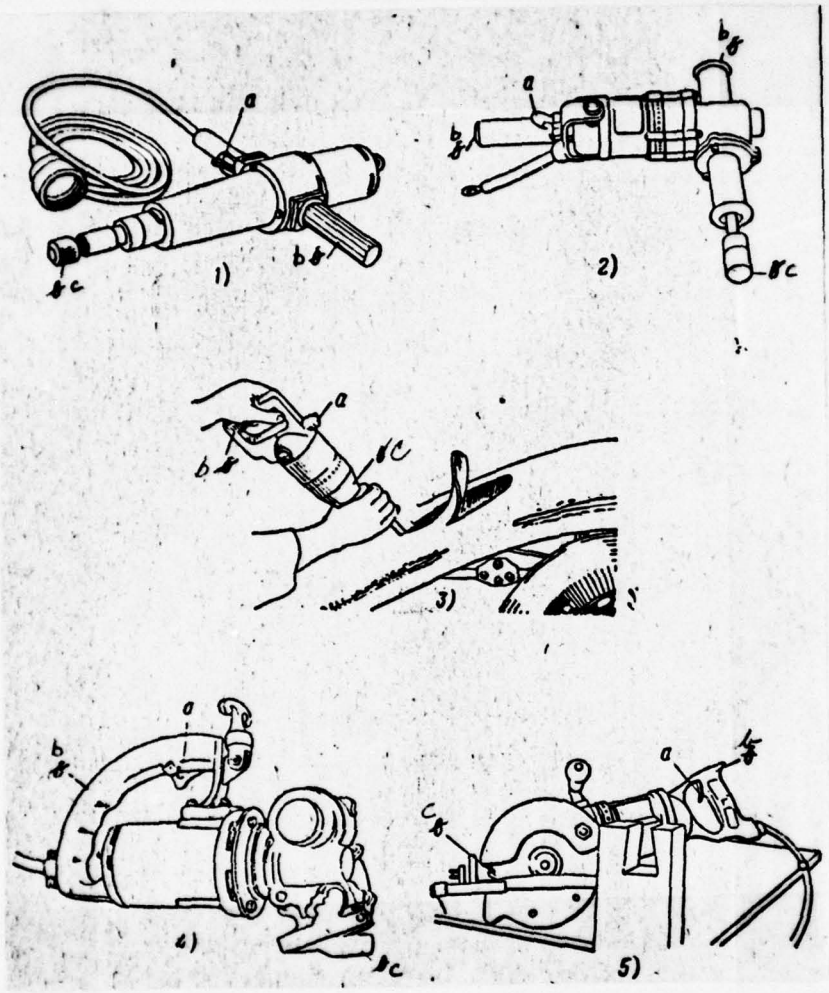


Fig. 62. Examples of the different application/use of a power tool. 1 - electric drill for drilling of holes, 2 - electric wrench for screwing up and unscrewing of nuts and bolts, 3 - electric hacksaw for cutting of metal, 4 - electric shears for cutting of sheet steel with a thickness of 1.5 mm, 5 - electric saw (a) switch, b) handle, c) instrument).

Page 128.

At Soviet plants are manufactured power tools up to 1 kW in power, working on alternating current 50 or 200 Hz with voltage 36 V. Therefore, power tools operating at voltages no higher than 36 V and especially at the increased current frequency, can find use under dangerous conditions for powers on the order of 1 kW (Fig. 63).

The application/use of hand tool with normal operating voltages from 110 to 220 V represents the determined danger of damage/defeat by current with the nonobservance of the precautionary measures.

According to operating "technical operation instructions and safety of the maintenance of the electrical devices of industrial enterprises" is permitted to apply the instrument with electric drive voltage: in locations with the increased danger - it is not above 220 V; in locations especially dangerous and outdoors - are not above 36 V. With the impossibility to utilize a power tool to 36 V its due to

insufficiency power is allow/assumed the work with power tool to voltage to 220 V inclusively. But in this case is necessary the reliable grounding of the current-conducting housing of power tool and use by worker of protective agents as that: dielectric gloves, overshoes, floorings, aprons (depending on work conditions; Fig. 64). In these cases is very expedient the application/use of remote control.

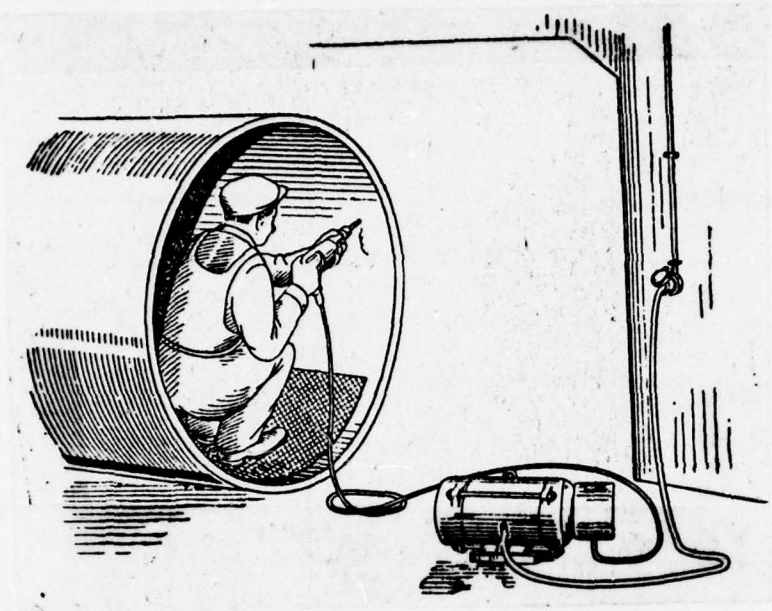


Fig. 63. Electric drill I-74 with frequency converter.

Page 129.

Very construction of power tool must provide complete safety with the use by it. This power tool is shown to Fig. 65. The locating under voltage parts of the manual power tool are arranged so that is eliminated the possibility of touch to them. The jacket of the instrument, intended for a work with voltage is above 36 V, it is equipped by special terminal/gripper for grounding or

connection to neutral not less than 4 mm in diameter. The earthing clip must be provided for from inside of the housing of instrument.

Power tool must rapidly be included and be disconnected and not allow/assume spontaneous connection/inclusion and disconnection/cutoff.

The position of switch is marked on the housing of instrument by labels "On" and "Off". Instruments with electric drive must be ganged equipped by four-contact or three-pronged bullet connection and hose wire with the appropriate number of wires.

As lead wire for an instrument, must be used the rubber flexible hose wire, four-strand - for the instrument of three-phase current and three-strand - for single-phase.

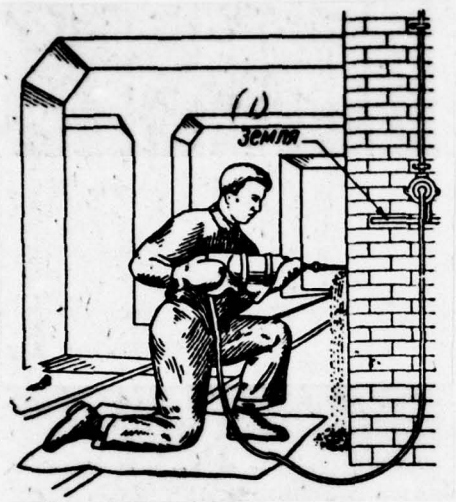


Fig. 64.

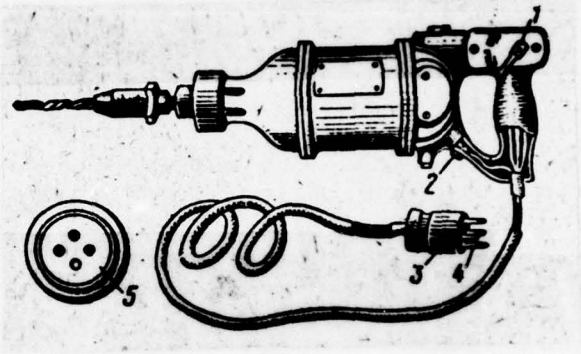


Fig. 65.

Fig. 64. The application/use of a power tool with voltage above 36 V.

Key: (1). Earth.

Fig. 65. Safe power tool. 1 - switch, 2 - ground wire, 3 - special plug, 4 - the contact of grounding; 5 - plug socket.

The fourth vein/strand for the instrument of three-phase current and the third vein/strand with single-phase current, the intended for a grounding housing of instrument, must be noted by distinctive color. Ground wire by one its end/lead must be solidly connected with the housing of instrument by the means of special terminal/gripper (screw/propeller), and by another - be connected tightly to the grounding contact of plug.

Insulation separations must be with the necessary reserve of dielectric strength. All the current-carrying connections and contacts must be mechanically durable.

The construction of power tool must be tested on dielectric strength by voltage not below 1500 V. The knob/sticks of switch and the housing of power tool itself for the purpose of electrical safety one should make from durable moulded insulation. The wires, which supply current, must be shielded from mechanical damages and have the appropriate device, which prevents them from rapid wear in the places of the input/introduction into the housing of power tool.

Under the affect of production and atmospheric conditions the insulation of electrics in the course of time breaks down itself; as a result the metallic part of the power tool, intended for the enclosure/protection of electric motor and its current-carrying parts, can render/show under voltage and cause lethal injury. Therefore is first of all necessary equipment/device of reliable shielding or grounding of the metallic parts of the instrument and periodic inspection of its state. Furthermore, power tool must be shielded by the safety fuses. In connection with this bullet connection for the inclusion of power tool into network together with the safety fuses must be considered as integral part of the power tool.

By the most rational solution to the question concerning the electrification of hand tool from the viewpoint purely production is the application/use of a high-frequency current (to 200-500 Hz). The major advantage of high-frequency instrument is high productivity and considerably smaller weight in comparison with the power tool, working on the current of single frequency (50 Hz).

According to the published data, the specific power of the power tool of alternating current with 50 kg is equal to 30 W/kg, and high-frequency - 110 W/kg. The weight of the manual power grinding machine of alternating current with a frequency of 50 Hz is 13 kg, and with the current with a frequency of 150 Hz - a total of 5 kg. Are analogous data also for the electric drills: with the current with a frequency of 50 Hz the weight of electric drill is equal to 4.4 kg, and with the current with a frequency of 150 Hz - 1.1 kg. Furthermore, the power tool of high frequency has certain advantage in the relation to the safety of work. An increase in the frequency to 1000 Hz and above more will even considerably facilitate the weight of instrument and with respect it will lower the dangerous effect of current itself.

The safety of power tool is provided not only by construction, but also by correct operation and supervision after its state.

Page 131.

In operational procedure about use by a power tool, must be clearly noted all torque/moments, connected with the

danger of the electrotraumas: need preliminary protective grounding of jacket; the need for the inclusion into network with respect to the voltage, indicated on the panel of power tool; the inadmissibility of the use of defective instrument or wires with defective insulation, etc. The soundness of instrument must be checked every time before its delivery for a work.

Power tool together with wires it is expedient to secure to the determined face, for example to the foreman who must follow working order of instrument. Workers must be well informed about all dangers of electric current with the use of power tool, and also about protective measures from the danger of damage/defeat and the methods of rendering of first aid.

Independent of the character of locations and conditions of work, all power tools, working with voltage above 36 V, must be grounded.

In the determined places of production location must be provided for equipment/device of special plug sockets with grounding (neutral-connected) contacts for the inclusion into the network of movable electric appliances (power tools,

vacuum cleaners, electric stoves, electric welding transformers, etc.) with the simultaneous provision for them with shielding grounding (connection to neutral).

Monitoring of safety and working order of power tool is charged to the face, specially for this authorized by order on enterprise. Power tool must have the reference number and be stored in dry location, in cabinets or shelves.

8. Power plants.

The electric drive must be arrange/located so that it would be convenient and it is safe it to operate, to overhaul and routine repair.

Electric motor as any part of the electrical device, depending on its design can be to a greater or lesser extent subjected to the destructive effects of the environment (moisture, dust, gases, etc.). Reliable and safe work is provided by the application/use of electric motors of such construction during which they are sufficiently

shielded from external damages and the destructive effects. Depending on this, are applied the open, closed, shielded, pressurized/sealed and explosion proof electric motors (Table 21).

That which was opened he is called the electric motor at whose current-carrying parts do not have special coatings. Such electric motors are most cheap and have minimum sizes. The absence of protective housings provides good natural ventilation, good heat removal and, therefore, the high use of an active material.

Page 132.

However, to apply such electric motors is possible only in the dry nondusty locations, which do not contain vapors, acids and other harmful isolation/liberations.

To Fig. 66a, is shown open type electric motor, not shielded from dust and moisture. The presence of the open current-carrying parts and revolving parts creates on the one hand the danger of damage/defeat by current with the random touch also of injuries, with another - the possibility of short circuits with incidence/impingement to

the current-carrying parts of any current-conducting object/subjects. Therefore the indicated type of electric motor can find finding.

To Fig. 66b, is shown shielded type electric motor. It is manufactured also with dampproof insulation for a work in humid medium and on the open air.

With the possibility of damage from the penetration of foreign objects, moisture or dust, one should apply electric motors with protection or with special insulation of windings.

Table 21.

(1) Характеристика помещения	(2) Тип двигателя
(3) Сырое помещение	(4) Электродвигатель с влагостойкой изоляцией и с защитой от попадания капель
(5) Пыльное помещение, когда пыль или волокна, оседающие на обмотках электродвигателя, нарушают нормальное охлаждение или вредно действуют на изоляцию (котельные, цементные заводы и т. п.)	(6) Электродвигатель закрытый или продуваемый чистым воздухом
(7) Пыльное помещение при непроводящей негорючей пыли, легко удаляемой продувкой и не оказывающей разрушительного влияния на изоляцию	(8) Открытый электродвигатель
(9) Помещение сырое и одновременно пыльное, а также помещение с проводящей или горючей пылью	(10) Закрытый электродвигатель
(11) Помещение с едкими парами или газами	(12) Закрытый электродвигатель в герметическом исполнении либо закрытый продуваемый электродвигатель с кислотоупорной изоляцией
(13) Пожароопасное помещение	(14) Электродвигатель выбирается в соответствии с разд. „Электрооборудование пожароопасных помещений" „Правил устройства электроустановок"
(15) Взрывоопасное помещение	(16) Электродвигатель выбирается в соответствии с разд. „Электрооборудование взрывоопасных помещений" „Правил устройства электроустановок"

Key: (1). Characteristic of location. (2). Type of engine. (3). Damp/crude location. (4). Electric motor with moisture-proof insulation and with protection from the incidence/impingement of drops. (5). The dusty location when dust or the filaments, which settle during the windings of electric motor, disrupt normal cooling or detrimentally they operate on insulation (boiler, cement works etc.). (6). Electric motor closed or blown by pure air. (7). Dusty

location with nonconducting incombustible dust, by the easily driven out purging and not having destructive effect on insulation. (8). Open electric motor. (9). Location damp/crude and is simultaneous dusty, and also location with the conducting or combustible dust. (10). Closed electric motor. (11). Location with caustic vapors or gases. (12). Closed electric motor in pressurized/sealed performance or the closed air-blast electric motor with acid-resistant insulation. (13). Flammable location. (14). Electric motor is selected in accordance with Section. "electrical equipment of flammable locations" the "rules of equipment/device of electrical devices". (15). Dangerously explosive location. (16). Electric motor is selected in accordance with section. "electrical equipment of dangerously explosive locations" the "rules of equipment/device of electrical devices".

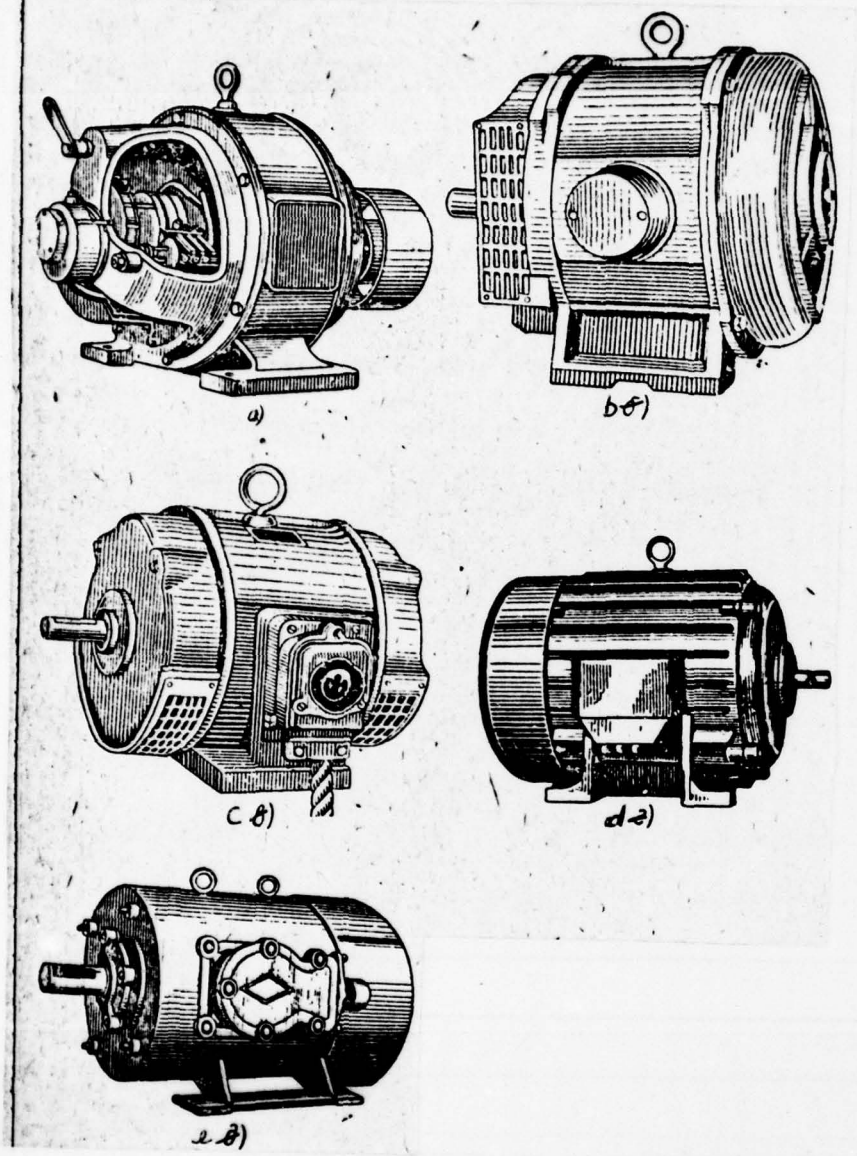


Fig. 66. Electric motors of different types. a) open electric motor, b) electric motor shielded from the incidence/impingement of foreign objects, c) the electric motor, shielded from the drops of water and oil, falling/incident is vertical or at an angle of 45°, d) closed electric motor, e) explosion proof electric motor.

Page 134.

Depending on the kind of protection, distinguish electric motors the simply shielded, shielded from drops water and oil (Fig. 66c) and shielded from water spatters. From dust and gases, the indicated types of electric motors are not shielded, since they are cooled by the air, which enters from the environment through the gaps between the electric motor and protective coatings.

In locations with the contaminated air from penetration of which the engine must be shielded, are applied closed electric motors (Fig. 66d).

Depending on the method of cooling, closed electric motors are manufactured with tubular connection, with the coolant jacket and dead ended.

Closed electric motors with tubular connection take place special for the connection of the tubes, which supply and which discharge air coolant. For air circulation, the electric motors within jacket have a fan.

Electric motors with the coolant jacket are included into metal casing. Between jacket and housing of electric motor, there is a gap for air circulation which cools electric motor. Air is suckked in with the aid of the fan, adjustable outside after the end shield.

Dead ended electric motors have neither supply nor of the removal/outlet of air coolant. Cooling occurs exclusively as a result of the heat emission through the metallic housing of electric motor and natural washing by air. Therefore the power of completely closed electric motors is less than the power of the open electric motors of the same size/dimensions.

Besides closed electric motors, are manufactured the special explosion proof electric motors whose constructions are varied depending on the conditions of their operation (Table 21, see page 132).

To Fig. 66в, is shown explosion proof electric motor for a work under conditions where is not excluded the possibility of blast (methane, coal dust).

Thus, for production locations by the best types of electric motors one should recognize closed and explosion proof.

The setting up of the open and shielded electric motors as cheaper in comparison with closed and explosion proof is not justified. Sometimes such electric motors for a preservation from the current-conducting dust, which is formed during production process (for example, in work on the machine tools), cover/coat with specially iron jackets. This disrupts normal ventilation and it impedes the heat emission of electric motor. Insulation of the winding of electric motor is superheated and breaks down itself, creating conditions for the transition of voltage on housing with all escape/ensuing from this consequences, especially if the housing of electric motor is nongrounded.

Page 135.

It is obvious, similar savings of the cost/value of electric motors reduces to zero, since are required supplementary expenditure/consumptions in connection with the

damage of electric motors, the unavoidable material losses, caused by idle time of production mechanisms, by nonperformance of plan/layout, the repair of electric motors, etc. Furthermore, deteriorate the conditions of safety. During the setting up of the closed or explosion proof electric motors, which require high first costs, are provided satisfactory work and the life of electric motors under the most adverse conditions and are reduced to the minimum expenditures for the repair of electric motors.

For the mechanisms, working with emulsion, it is expedient to provide the emulsion pumps, which operate through the transmission from electric drive. Practice showed that the direct-motor drive of the pump, feeding emulsion, works under very severe conditions and to ensure the life of this electric motor without the rise in price of construction is impossible.

The individual protection of electric drive from the short-circuit current and overloading is achieved by the setting up of safety device/fuses and separate switches of contactor, which makes it possible to rapidly disconnect electric motor from network.

For the electric motors whose self-start can constitute a threat to maintenance, is provided for the protection of minimum voltage.

Independent of the type of electric motor it is necessary to ensure the proper quality of the mounting of electric wiring to it. Very frequently during good construction of electric motor as a result of unsatisfactory contact are not provided reliability and the safety of work. Thus, for instance, terminal terminal boards in certain cases remain opened, exposed and their contamination, which can cause damage/defeat by current, short-circuiting or closing/shorting to the earth, and for the majority of contemporary electric motors generally are absent terminal for connecting the wires (Fig. 67); can be also unsatisfactory wire insulation.

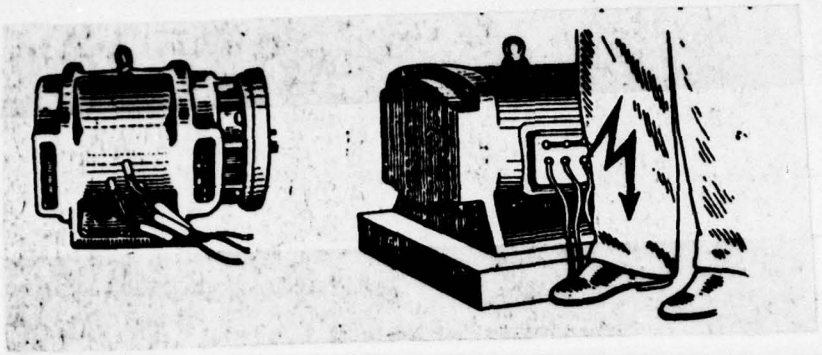


Fig. 67. Method of the connection of wires to electric motor, which represents the danger of electric shock.

page 136.

Therefore the electric wiring, carried out by cable or wires in tubes, it is necessary to feed/conduct directly to grip cheeks of electric motor, without allow/assuming the unprotected parts of the electric wiring. Terminals must be reliably protect/surrounded from random touch to them.

Entire electrical equipment for the launching/starting of electric motor and protection from short-circuit currents to avoid contamination and transition of voltage on housing must be shielded by sufficiently airtight jackets.

The housing of electric motors, starting/launching and adjusting devices are grounded according to operating rules.

All cell/elements of installations - electric motors, equipment for control, which controls start, inspection and measurement and shielding equipment, and also all the electrical accessory equipment - in form of performance must correspond to environmental conditions.

The revolving parts of the electric motor - fans, the open parts of the shafts, blocks, clutches - reliably are guarded.

The starting equipment of electric motors to voltages is above 1000 V, establish/installed directly in production location, must be reliable closed by the dead/blind panels, which are open/disclosed either by special key/wrench or with the aid of the loosening of nuts or bolts.

Each electric motor, as a rule, is supplied with the separate control device. With voltage 500 V for the group of electric motors, is allow/assumed the application/use of a common/general/total starting/launching apparatus, if this is justified by the requirements for convenience or safety

of operation, for example, when several electric motors they serve for the drive of one machine or series of the machines, which realize/accomplish a single technological process.

If the group of electric motors is supplied from common/general/total main line and serves for the drive of the mechanisms, which realize/accomplish a single technological process, for a disconnection/cutoff from the voltage of all circuits of the indicated group of electric motors, it suffices to have one master switch, establish/installed in the beginning of main line.

The devices of control and the disconnecting vehicles, adjustable in production locations, must be shielded from random touchs to current-carrying parts, but in the case of necessity - and of the harmful effects of the environment.

In the settings up in which the given mechanism or its separate parts are removed from control post (for example, with the long transporters), are provided for the knob/buttons of safety for the disconnection/cutoff of electric motor from the place of location of the removed parts of the mechanism, if this is caused by the

requirements for safety. Furthermore, in the similar cases it is necessary to equip the light and sound communication, interlocked with launching/starting and stop of electric motors.

The electric motors, subjected to separation, must be shielded from an excessive increase in the speed.

As it was already said that electric drive must be arrange/located so that it would be convenient and it is safe to operate it, to inspect and to transport into shop for the production of repair on the spot.

Page 137.

With the weight of equipment or separate parts of it in 100 kg and is more necessary to apply lift and movable devices - electrical tap/cranes, hand cranes, trolleys, etc. For the safe maintenance of the electric motors, arrange/located at height/altitude it is above 3 m, must be arranged constant staircases.

All electric motors for the connection of wires must have the terminal boxes with those derived in each of them

as six terminals-clamps. All coil leads must be marked. The connection of electric motors to their feeding wires without connection to terminals is forbidden. The cable box (funnel) or tube with the laid in it wires, which connect electric motor, will be feed/conducted directly to the terminal box of electric motor. Coil leads and the cable terminals or the tubes, lead wires, must be closed by the enclosure/protections whose removal/taking would be impossibly without the loosening of screw/propellers or bolts.

Connection/inclusion and the disconnection/cutoff of electric motors with the aid of bullet connection are recommended at the power of engine not more than 0.5 kW. In the power of engine of more than 0.5 kW, should apply interlocked bullet connections in which the connection/inclusion and the disconnection/cutoff of electric motor is possible only with the removed voltage.

If the stop of the electric motor of any mechanism, entering the production line, can involve danger for the service personnel, energency or the damage of production, are provided for the corresponding blocking and signaling.

On each rheostat must be distinct markedly the

position, which corresponds to the connected or off rheostat, and also the position of intermediate step/stages. Liquid resistance are supplied with liquid level gauge and with devices for exhaust of the forming vapors. Rheostats and resistor/resistances are establish/installed in available for maintenance places on flameproof foundations.

In the construction of starting/launching equipment, must be eliminated the possibility of starting of electric motor with the open doors or the removed cap/covers of the jackets of starters. Electrical circuit and the design of starting/launching equipment also must not allow/assume the closing/shorting short of wires in the circuit of the remote control, which is capable of leading to starting of electric motor.

As starting/launching equipment for the direct connection/inclusion of electric motor with short-circuited rotor wide acceptance received the so-called magnetic starters. They possess the enormous advantage, that they are service/maintained remotely, by the knob control, arrange/located independent of starter in most convenient and safe places.

Page 138.

Magnetic starter is metallic cabinet with the tripolar contactor of alternating current and the two-pole thermal relay, mounted on insulating plate/slab. Upon incidence/drop or disappearance of voltage, the contactor automatically is disconnected. For its connection/inclusion it is necessary to press start button. Overload protection is provided by the thermal relay which, however, does not provide for protection from short-circuit currents. Design and diagram of magnetic starter are given to Fig. 68.

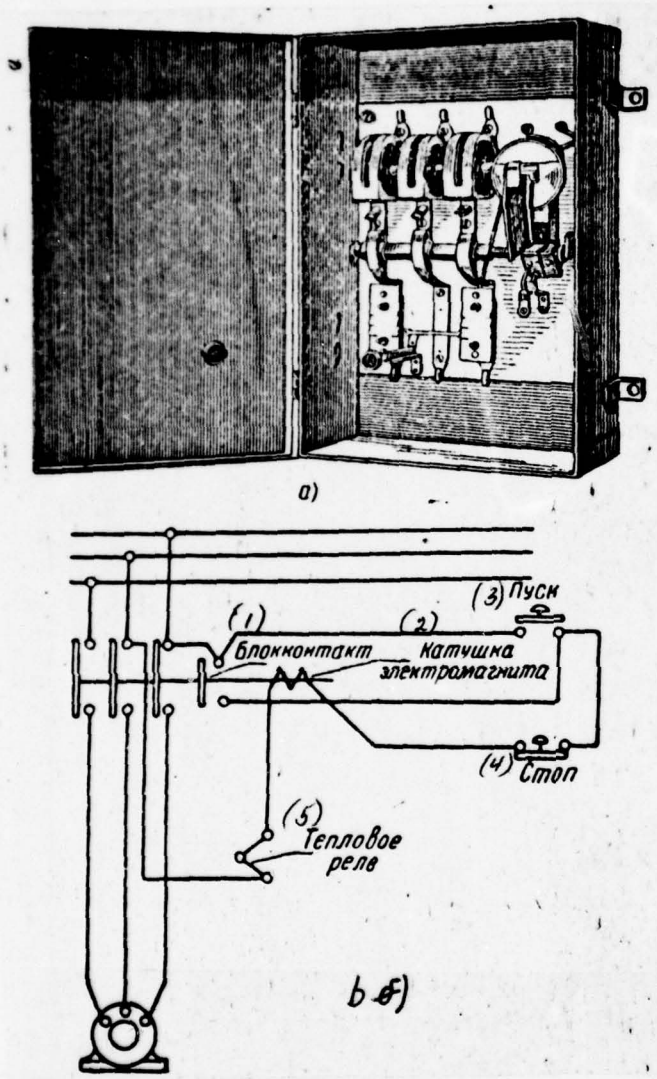


Fig. 68. Magnetic starter. a) general view, b) the diagram of magnetic starter.

Key: (1). Contact block. (2). Magnet coil. (3). Launching/starting. (4). Hand/foot. (5). Thermal relay.

The construction of starting/launching equipment must not controlled into the work of electric motor with the open doors or removed cap/covers of the protective housings of starters.

All electric drives of mechanisms with large running-light currents must have the automatic disconnection/cutoff of idling.

Knob/buttons for control of electric motor must be also closed or explosion proof fulfillment. Must be manufactured them from mechanically durable colored moulded insulation. To avoid the connection/inclusion of electric motor with random pushing of knob "launching/starting" it is necessary to establish/install flush-type knob/buttons (Fig. 69).

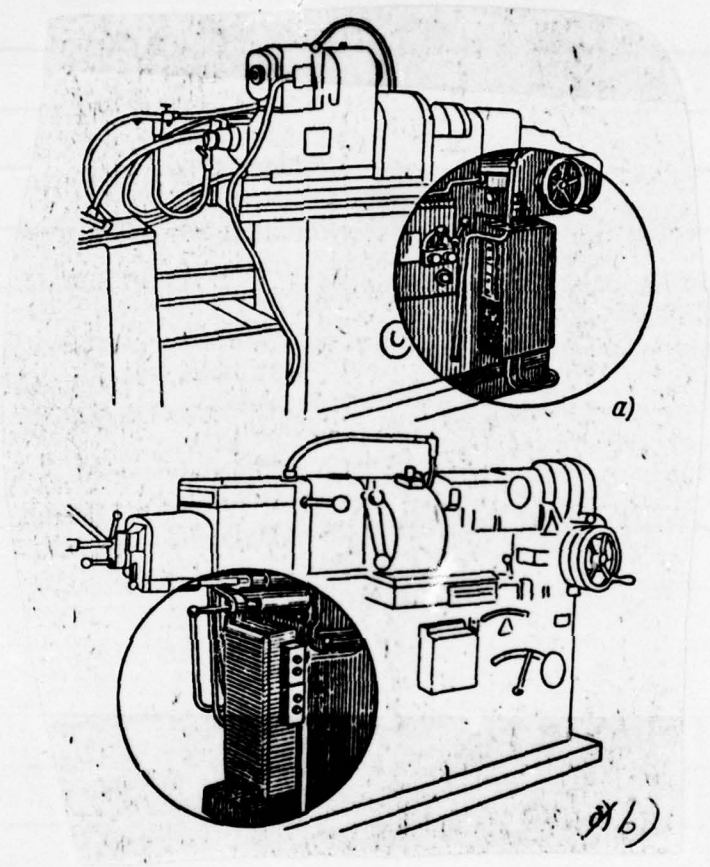


Fig. 69. Knob control. a) flush-type knob/button; b) projecting type of button.

Page 140.

For rapid orientation in work, one should paint

knob/button "launching/starting" with green or black paint, the knob/button of "Beam/feet" - red. In addition, the designation/purpose of knob/buttons should be shown by metallic stencils with the appropriate labels: "launching/starting", "Beam/feet", "forward", "back/ago", and ~~the like.~~ etc.

Push-button controls group must be establish/installed in the places, which ensure safety and convenience in the maintenance. If the reliable shielding grounding of the case of knob control is difficult to achieve, for example for electric transport devices (power carriage, power block and tackle), then one should apply the cases from moulded insulation, which ensure greater safety and the not requiring groundings. During the arrangement/permutation of electric motor at considerable distance from of the given by it into action mechanism, must be provided for the possibility of the stop of electric motor from any place of the maintenance of this mechanism. In similar cases it is necessary to also ensure the two-way signaling, which creates safety in the work of production mechanisms.

The examined requirements for electrical safety are related in equal to measure to electrical machines in general.

general.

9. Electric cranes and hoists.

Lifting-transporting devices in the form of electric cranes, it is monorail and telphers they are made in accordance with the rules of device, examination and operation of tap/cranes, of hoists and auxiliary with them devices, developed by state boiler code committee.

The operating voltage of electric cranes and hoists must be not above 500 volts. Trolley wires can be applied steel - rigid and flexible. In the case of the motionless attachment of trolley wire on final and inner bearings, the distance between supports must be not more than 6 m. With the free suspension of the trolley wire, rigidly strengthened only at end points and freely hung in inner bearings, the distance between the supports can be no more than 8 m. The height/altitude of the suspension of trolley wires must eliminate the possibility of random touch to them from sex/floor, the earth/ground and working areas.

With free suspension must be provided automatic disconnection/cutoff from the network of all trolley wires in the case of the break of any of the main trolley wires.

Clearance among the parts of current pickup, among by trolley wires, the parts of current pickup and by the parts of buildings, by metal structures etc. is establish/installed not less than 5 cm.

The possibility of the contact between themselves of trolley wires, the parts of current pickup, and also between them and cargo cords must be excluded. Special enclosure/protections on tap/crane make impossible random touchs to the trolley wires, which go along shop. The enclosure/protections not are obligatory, if main trollies are arrange/located at a distance, not exposed to them from tap/crane.

Page 141.

Main trolley wires from the inoperative surface must be painted in bright color for their clear isolation/liberation from structural and technological constructions. Trolley wires

on tap/crane must be arrange/located above the farm/truss (bridge) of tap/crane, with the exception of the special tap/cranes, which do not allow/assume this arrangement/permutation of wires. In the last/latter cases of wire, they must be arrange/located under the flooring of farm/truss or protect/surrounded so that the touch to them it would be impossible.

For the disconnection/cutoff of main trolleies from power supply, is establish/installed in available for a rapid disconnection/cutoff places the switch, in closed housing, with device for a lock to lock in off state. It is expedient to provide the signaling of the remote disconnection/cutoff of switch from the cabin of crane driver.

The cover of the hatch, which leads from the cabin of crane driver for the flooring of the farm/truss of tap/crane, must be equipped with device of the blocking, which automatically disconnects trolleies on the farm/truss (bridge) of tap/crane with the opening of hatch and output to bridge. In this case, reversal of trolleies under voltage after the closing of hatch cover is possible only from cabin after the preset of handles or flywheels of all

controllers to zero position.

Device for the automatic disconnection/cutoff of trolleies on to bridge on leaving from it is linked not only with the opening of hatch cover, but also with the split part of the rails (door) of the end beam of tap/crane in the place of input to bridge, if input to the tap/crane through the bridge is solved by boiler code committee.

If the cabin of crane driver is fastened on cargo crane truck, then the automatic disconnection/cutoff of trolleies on to the bridge of tap/crane on leaving to bridge is conducted by the linear contactor, arrange/located on to bridge. Control of this contactor is conducted from the cabin of crane driver by the means of supplementary undetachable trolleies, which are located under voltage not above 36 volts.

In the case of the feed of electric crane from the network of direct current, undetachable trolleies to linear contactor must be arrange/located under the flooring of bridge or protect/surrounded so that the random touch to them it would be impossible. If in this case in cabin is

provided for output to flooring, then the device, which automatically disconnects trolleies on to bridge, is linked with the split part of the rails (door) in cabin, that separate/liberate the work site of crane driver of staircase.

Output to the flooring through the hatch from the cabin, strengthened to cargo crane truck, is not allow/assumed.

If from the cabin, strengthened to cargo trolley, output to flooring is conducted from the landing field, which has constant staircase, or from the gallery of crane runway, then the automatic disconnection/cutoff of trolleies on to bridge must be interlocked with the detachable part of the rails of the end beam of tap/crane.

Of the revolving (tower) tap/cranes, if cabin is arrange/located on the revolving part of the tap/crane and the input into it is provided for from within tower, the opening of the cover of the hatch of cabin is blocked with the disconnection/cutoff of the electric motor of rotating mechanism.

Page 142.

With the disconnection/cutoff of the electrical equipment, establish/installed on tap/crane and hoist, the illumination is not disconnected.

Voltage for the general illumination on the farm/trusses of tap/crane and hoist is allow/assumed not more than 220 volts [1].

FOOTNOTE [1]. Under the condition of the arrangement/permutation of illuminating lamps at height/altitude it is not less than 2.5 m. ENDFOOTNOTE.

Illumination in cabin with voltage 220 volts can be allowed in such a case, when are utilized the special reinforcement of illuminating lamps and the electric wiring, which eliminates admission to current-carrying parts, that are located under voltage.

The voltage of repair illumination is recommended not above 12 volts. Plug rocket must be establish/installed in

cabin. Electrical wiring in cabin, on tap/crane and hoist is made in steel tubes or by cable for protection from mechanical damages. So that all equipment components, arrange/located on tap/crane and which is located under voltage, would be not available for a random touch, are applied the corresponding continuous enclosure/protections, blockings and the automatic disconnection/cutoffs of trolleies on leaving to bridge. Specifically, must be unavailable the current-carrying parts, arrange/located not only from of face, but also from the back distributive sheet rubber.

All enclosure/protections of electrical equipment of the distributing frame (panel, controllers etc.) are fastened reliably and solidly into avoidance from displacement in the work of electrical tap/crane.

The width of passages into the cabin before the face of the distributing frame or magnetic panels is accepted not less than 600 mm. It is necessary that the location of instruments would provide to crane driver the possibility of the safe tinning of tap/cranes. Control handles must be conveniently arrange/located, mechanically be held in the determined positions with the aid of springs and have a designation of the direction of motion, speed, and zero positions.

positions.

All the metallic structural/design parts of the electrical equipment of tap/cranes and hoists - the housings of electric motors, controllers, the jackets of equipment, cabinets of resistor/resistances and so forth, and also metal construction, crane rails and crane runways - are grounded in accordance with the rules of the device of grounding in settings up by the voltage to 1000 volts.

The device of cabin and the arrangement/permutation in it of electrical equipment must provide to crane driver possibility, without converging from place to control tap/crane and convenient to survey operated by tap/crane area.

The cabins of tap/cranes are placed under the flooring of bridge and are communicated with flooring with the aid of staircase with handrails. Cabin is arranged of the metallic parts not less than 1.8 m in height; its sex/floor must be the wooden, covered rubber flooring. Cabin is supplied with continuous or mesh enclosure/protection from all sides not less than 1 m in height with moving from within door for an input, if input to the bridge of

tap/crane is arranged through the cabin.

Page 143.

The cells of the enclosing grid are made with size not more than 2 X 2 cm. Grid from below on 15 cm is supplied with sewing to avoid precipitation of any object/subjects from cabin.

On all pads, the balconies, service galleries of tap/cranes and hoists, and also of the end beams of the bridge cranes must be made the enclosure/protections with a height/altitude of 1 m with continuous sewing on base to height 15 cm. On vertical staircases whose height is more than 5 m at a distance 3 m of floor level arrange special enclosure/protections in the form of the metallic arcs, distant from each other not more than on 0.8 m.

In metallurgical plants the protection of crane drivers from the action of radiant heat is conducted by means of device in the cabin of flooring from the material, which badly/poorly carries out heat. Cabin itself is made from the incombustible material. In cabin are must constantly it is located staircase from steel cable for the output of

crane driver from cabin in the case of emergency. In the closed cabin of crane driver, who operates metallurgical plants, besides the observance of requirements indicated above, one should have inside forced ventilation.

In shops with the wide application of electric welding work it is necessary to provide for the protection of crane drivers from the effect of the ultraviolet radiations of electric arc.

In the shops where according to the conditions of production is possible the isolation/liberation of harmful vapors and gases, the application/use of tap/cranes with the cabin, strengthened to cargo crane truck, is forbidden.

Cabins for the tap/cranes, working in cold locations or in the open air, must be closed from all sides, are glazed and warmed. During the cold season of the year of cabin necessary to warm by the electrical furnaces of safe constructions.

Electrical tap/cranes are also equipped with a series of devices, which ensure their safe operation: by proper braking device, limiters of the motion of load capacity, by limit switches, by counterweights, indicators, by fire-fighting means, etc.

PART FOUR

ATMOSPHERIC ELECTRICITY

Chapter 24.

THUNDERSTORM PROTECTION OF BUILDINGS AND INSTALLATIONS.

1. Thunderstorm phenomena.

Thunderstorm is the complex phenomenon of nature, caused by the onset of the considerable electric charges in the atmosphere, with sufficient accumulation of which occurs the discharge between two dissimilar charged clouds, either the cloud and the earth/ground or thereby and by others (Fig. 210).

The Earth is enormous conductor with extremely large reserve of the electricity of negative charge, equal on

calculations Q = 5.4 • 10^5 k.

In the atmosphere, which surrounds the earth/ground, there is an electric field, directed normal to the earth's surface. The conductivity of air in the atmosphere with distance from earths surface decreases; therefore the strength of field does not remain constant/invariable - it with respect decreases. So, if at level of sea the strength of field in clear weather amounts on the average to of 120 V/m (i.e. during lift on 1 m potential it increases by 120 V), then at the level 3 km the strength of field will be equal only to 25 V/m. At altitude 80 km, where the air becomes the same electro-conductive, as sea water, the strength of field composes a total of 4 • 10^{-8} V/m, potential earth referenced reaches value 200-213 kV.

To Fig. 211, are given the curved, characterizing change intensity/strength of field and potential in the height/altitude of the atmosphere, counting from the earth's surface, in clear weather. However, the strength of field and its potential will correspond to the indicated characteristics only in that condition that the earth's surface is the plane, which does not have the increased

object/subjects. In this case electrical field can represented by Fig. 212a, where the lines, which go in parallel to the earth's surface, show equipotential surface.

The increased on the earth's surface object/subjects or mountainous terrain substantially change the picture of the distribution of telluric field.

Page 451.

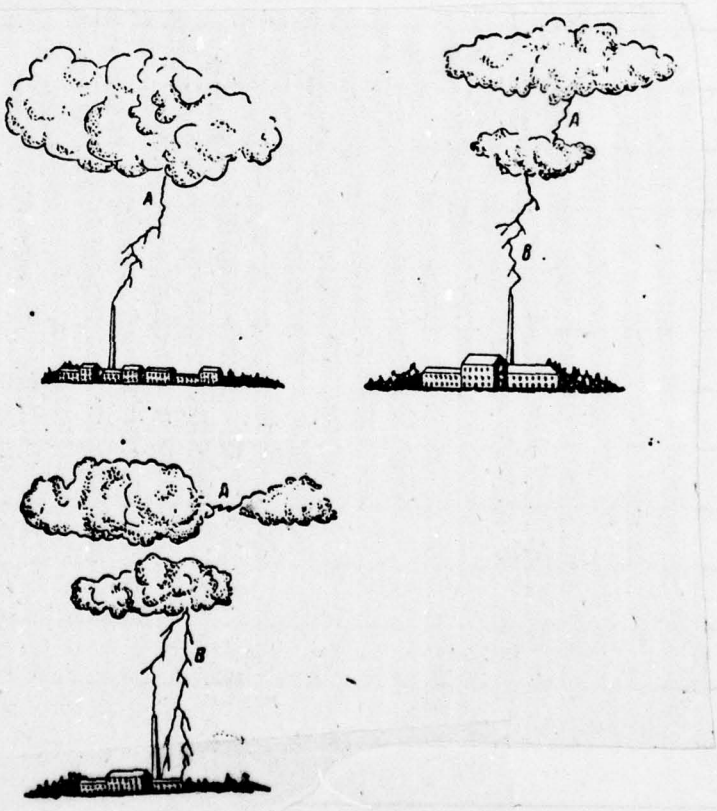


Fig. 210. Lightning discharges.

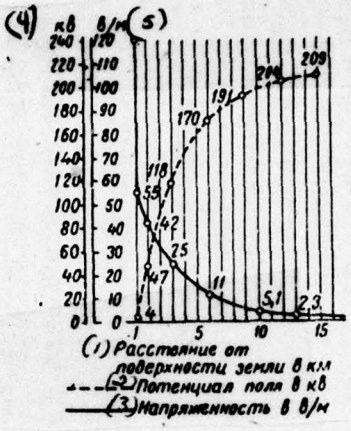


Fig. 211. Change in strength and potential of the field of the earth/ground in height/altitude from ground level.

Key: (1). Distance from the earth's surface 8 km. (2). Field Potential in kV. (3). Strength in water in oil. (4) KV. (5) water in oil.

Page 452.

Any increased object/subject of artificial or natural origin raises equipotential surfaces and draws together them between themselves, so that the strength also of potential draws together then between themselves, so that strength and the potential of electric field in these places can achieve the

significant magnitude (see Fig. 212b). This property of the increased object/subjects they use with the device of lightnings-arrestor, in order to create the previously outlined path for a lightning discharge and to ensure protection from damage/defeat to them (see Fig. 212c).

Because of the existence of electric field in the clear weather through the atmosphere, occur/flow/lasts to the earth/ground the electric current with average density $2 \cdot 6 \cdot 10^{-6}$ A/cm^2, comprising, with respect to the entire earth's surface, 1300 A. On the explanation of some scientists, this current is compensated for by the currents of thunderstorm discharges, since the otherwise electric field of the Earth would be eliminated. During thunderstorms the electric field undergoes abrupt changes, and the strength of field reaches the enormous values, which cause the phenomena of lightning discharges.

There is a series of scientific theories, which explain reasons and the picture of the onset of lightning discharges. Thunderstorm cloud is not a good conductor and possesses higher insulating properties, than dry air. This is explained to the facts that in the charged cloud there are no free electrons and ions, which cause the

conductivity of air, since, after arising, they they are connected, they are linked with water droplets they make little movable. Only during the onset of significant potential differences between the individual parts of cloud or the cloud and the earth/ground cloud makes well carrying out. With the accumulation of electric charges in clouds, the electric intensity and potential increase.

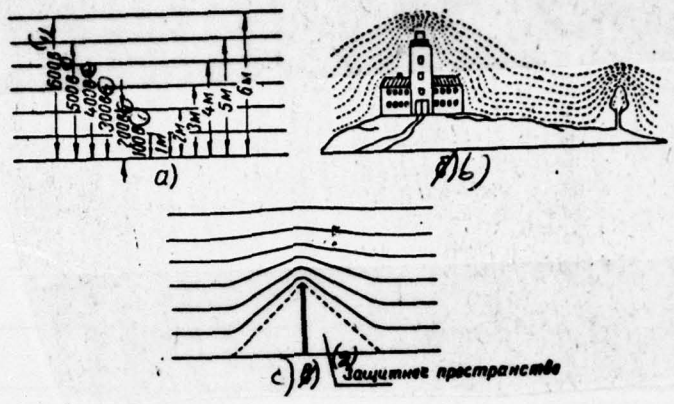


Fig. 212. Telluric field.

Key: (1) Volts (2) Shielding space.

Page 453.

Thus, for the onset of lightning discharge - lightning - it is necessary that the electric intensity of cloud would exceed its dielectric strength. With the indicated strength from the spherical surface of drops, will be begun bunch-like discharge. This discharge will create before itself the conducting path, thanks to which discharge will advance.

Molniya is the physical phenomenon of the violent discharge of the saved atmospheric electricity. This discharge is received by our view in the form of the igneous bands of zigzag, tape/strip or beaded form. Usually the phenomena of lightning are accompanied by sonic effect by the called thunder. Since the speed of sound is altogether only 330 m/s, and the speed of light - 300,000 km/s, the phenomenon of thunder delays in comparison with the phenomenon of lightning.

On the basis of numerous scientific experiments and investigations, are establish/installed the quantitative characteristics (parameters) of lightning, which make it possible or less soundly more to produce the calculation of the device of rational anti-thunderstorm protection. Are given below the quantitative characteristics of the thunderstorm phenomena according to I. S. Stekol'nikova's generalized data:

1) the intensity of the field of cloud of the earth's surface before the discharge is from 5 to 300 kV/m;

2) the potential of cloud - from 100 million to 1 billion volts;

3) time of the single discharge of cloud is from 15 to 1000 μs;

4) time of the full charge of cloud - 1.13 s.

The given characteristics are related to band or ribbon lightnings, which represent the greatest danger for ground-based objects. However, it is necessary to note that, besides band lightning as more rare phenomenon there is so-called globular lightning whose physical essence is still little studied. There is an explanation, that globular lightnings, which appear during the powerful lightning discharges in the form of igneous spherical bodies, are the higher connections of nitrogen with oxygen or ozone, which possess with property to be detonated during cooling.

Globular lightnings can not only deposit burns, but also mortally strike people and animals. They can cause also the decompositions of buildings. However, contemporary science still do not know sufficient means of defense from this very interesting phenomenon of nature.

2. Thunderstorm defeats of ground-based objects and people.

The probability of the thunderstorm damages of ground-based objects - buildings, installations, people, animal - is first of all determined by meteorological conditions and area relief. Furthermore, as shows research on this question and investigation of the individual cases of thunderstorm damage/defeats, soil conditions play also the important role in the formation/education of lightning discharge and explain the so-called selective vulnerability of lightning.

Specifically, the branched character of the separate discharges should explain by different ground conductivity. Speaking about branching of lightning discharge, incidentally it should be noted that if during branched discharge the hit probability into any point of the earth's surface is more than with that which was not branched, then with just one quantity of electricity, included in cloud, the branched discharges are less destructive.

Page 454.

It is obvious that one or the other quantity of thunderstorm cloud-to-ground discharges will depend to a considerable extent on the mutual placement of the area of the positive and negative charges of thunderclouds and on its location with respect to the earth's surface. The formation/education of thunderclouds and their location earth referenced in turn, is caused by the character of air currents and temperature conditions, i.e., by the aerodynamic and thermodynamic conditions, which have the here preceding value.

Thus, the weather condition as a whole determines the thunderstorm characteristic of one or the other area and predetermines the degree of its storm vulnerability. On the basis of statistical evidence and indications in the literature, it is known that the average annual quantity of thunderstorms, determined during the relatively prolonged period of time (is not less than 10 years), it remains for each area more or less constant. Having the indicated data, it is possible to dispose of the map/chart of storm

vulnerability, which makes it possible first of all to raise the question concerning the need or for the advisability of the device of anti-thunderstorm protection for the most beaten concrete/specific/actual locality.

For the characteristic of storm vulnerability vital importance they can have descriptions of individual cases of the thunderstorm damages of ground-based objects. These descriptions are also of scientific interest, since they make it possible in many respects to compare these or other the torque/moments of damage/defeat with the results of scientific-research work and to obtain in certain cases the critical evaluation of one or the other safety device and its value. Therefore is very important comprehensive research on the occurred in actuality lightning discharges, connected with those or another damage of ground-based objects. Unfortunately, not all cases of thunderstorm damage/defeats find the appropriate reflection in the literature and not always is given comprehensive description of all conditions of thunderstorm damage/defeat.

So that of the description of thunderstorm damage/defeats it would be possible to draw more or less full-valued conclusions on the questions interesting (for

example, about the coefficient of protection, the coefficient of damage/defeat, selective vulnerability and so forth), is necessary the examination/inspection of thunderstorm damage/defeat and its study to conduct according to the determined system in which most completely would be reveal/detected and were reflected all factors of thunderstorm damage/defeats. For this purpose it is possible to propose the following diagram of the examination/inspection of tunderstorm damages:

1. Place. Complete name and the address where occurred lightning discharge.

2. Date. Number, month, the year of the described phenomenon, the time of days (beginning and the end/lead of the observed phenomenon).

Page 455.

3. Meteorological conditions. Thunderstorm, rain, deg, the snow, the hurricane, the wind, the direction of the wind, wind velocity, the temperature of air.

4. Form of lightning. Band, continuous, is beaded,

spherical; with band lightning to note that is it branched towards the earth's surface silt not branched; at globular lightning indicator its value, color and form.

5. Path of lightning travel (according to data of direct inspection on the spot of discharge) with respect to ground-based object/subjects, place of its appearance, disappearance, traces.

6. Decompositions, produced by lightning. For determining zone of protections or lethal areas, is given the schematic layout of the affected object and its surrounding objects with the indication of their relative distance and height/altitudes in meters. It is important to apply to the plan/layout for the photograph of the place of damage/defeat with the mark of size/dimensions in plan/layout. Incidentally are indicated the paths of lightning and in what consisted its destructive action.

7. Presence of trees, basins and other object/subjects (electrical aerial networks) near affected objects. The character of soil is clay, sand, chernozem. Short characteristic and location.

8. Fires and damage/defeats. Are given detailed indications, was accompanied decomposition by fires, the defeat of people or animals. During people's defeat, it is noted whether aid was rendered and of what it consisted; which character of damage/defeat; with satisfactory issue for casualties from their words are indicated their perceptions and health.

9. Action of anti-storm protection. During thunderstorm damage of electrical devices and industrial enterprises, which have anti-storm protection, is indicated its action.

10. The cause of storm damage.

Besides the noted data, it is desirable to show all the supplementary torque/moments, which in more detail make it possible to refine and to present the picture of the occurred thunderstorm damage/defeat.

During this thorough and detailed description of each thunderstorm phenomenon, can be assembled rich statistical material.

It will be the valuable contribution to

common/general/total work on research on lightning, it will make it possible to check the results of scientific experimental investigations and expediently determine shielding actions.

Are given below short descriptions and the illustrations of some cases of thunderstorm damage/defeats.

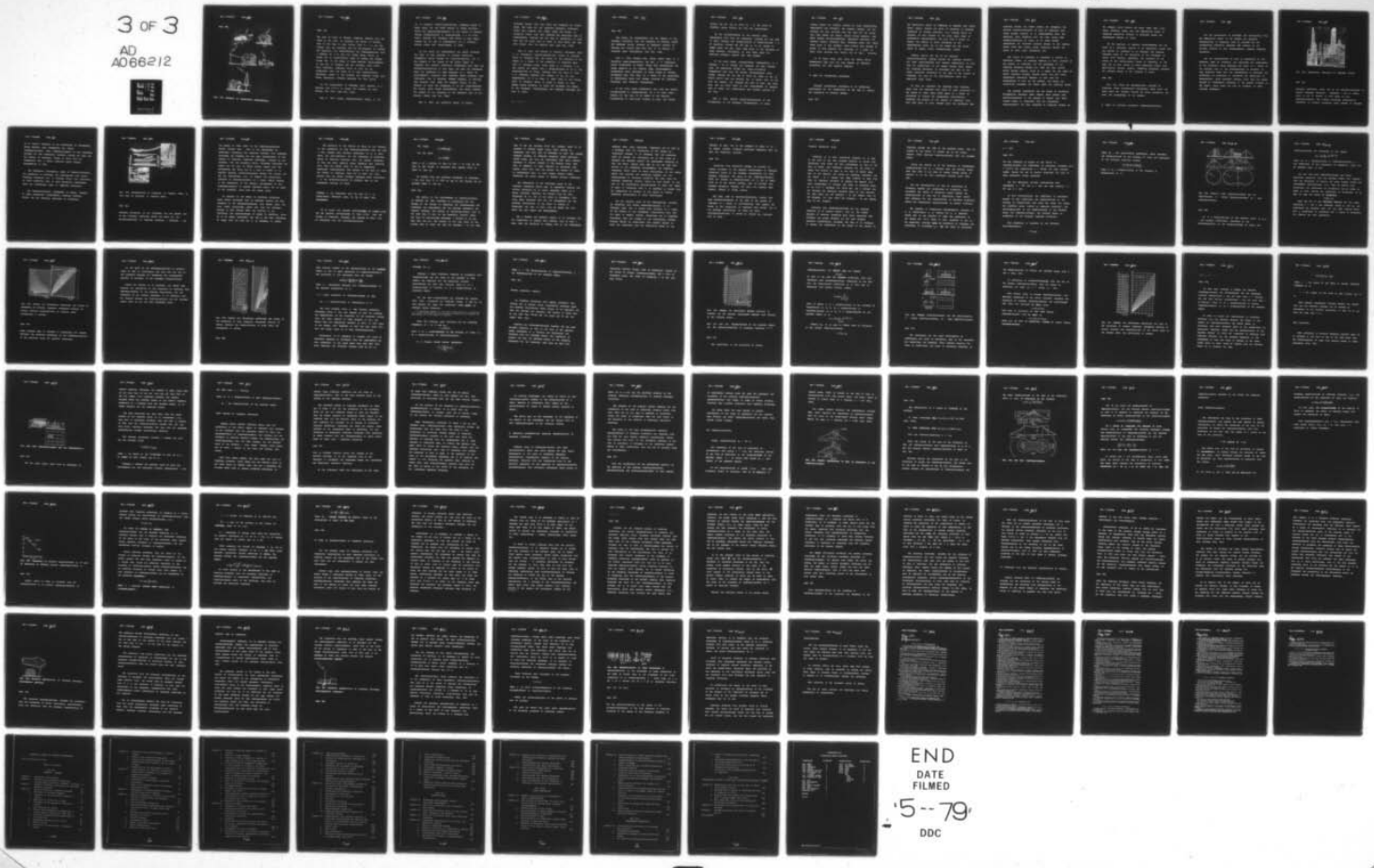
Case 1. 1936, the station at Yepifan' (eng. A. P. Belyakova's report/communication). On the open place on the way to city lightning struck to death woman, who went in auto. Chauffeur, who sat in front, remained living (Fig. 213a).

Case 2. 1931, Kalinin district, village pf Berezino (eng. A. P. Belyakova's report/communication). During the powerful thunderstorm, which was being accompanied by abundant rain, is struck to death by lightning the man, who was being located in wooden house.

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ELECTRICAL SAFETY AT INDUSTRIAL PLANTS. (CHAPTER 8 AND 24),(U)
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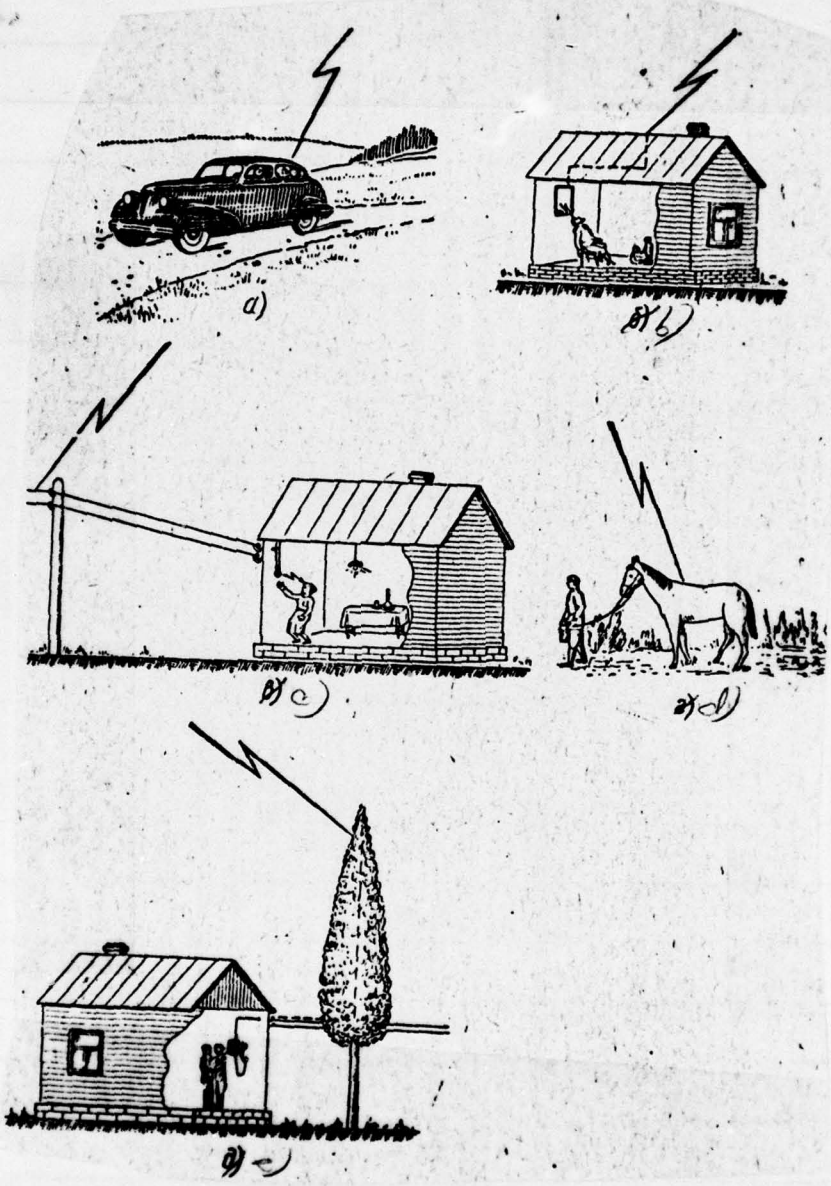


Fig. 213. Examples of thunderstorm damage/defeats.

Page 457.

The roof of house is shingle. Lightning hammered into the ridge of the roof, it traversed the garret to ceiling, then to the hung on wall mirror, from it - to man and further into the sex/floor and the earth/ground. In ceiling and sex/floor, are reveal/detected the opening/apertures with a diameter of 2 cm with the singed edges. Mirror is broken and is reject/thrown, glass in windows are broken, colors cut. In the house of large metallic object/subjects, it was not. On casualty was wet clothing, which could favor discharge. Lightning stroke by fire was not accompanied. Near the house of no high object/subjects (buildings, trees) it was located, and lightning stroke into house, apparently, occurred precisely for this reason.

At the torque/moment of discharge about casualty at a distance from 0.7-1.2 m, played the children who were stunned, but lived (see Fig. 213b).

Case 3. 1937, Moscow, Nizhniy-Novgorod street, d. 83

(A. A. Akopyan's report/communication). Lightning struck to death woman, who was being located in wooden barracks. During its approach/approximation to the switch of electric wiring, arrange/located to height/altitude 2 m of floor level, occurred the discharge from switch to head woman through the air gap of approximately 0.5 m. Casualty, without coming into consciousness, it died.

By the reason for damage/defeat one should recognize the drift of high potential in internal electrical illuminating wiring through air input/introduction. Due to the absence of the traces of the direct impact of lightning into external electrical illuminating line upon the examination/inspection of this case, was made the assumption about the appearance of high potential as a result of electromagnetic induction with lightning stroke hereabout from light-power line of barracks. Besides casualty, in barracks were situated other women who remained living. On the casualty of burns and blackening it is not reveal/detected. The reason, which caused damage/defeat, one should consider the absence of the grounding of the insulator pins of air electric system (see Fig. 213c).

Case 4. 1954; the collective farmer of kolkhoz

"Krasnaya gryada" went over field and conducted for bridle horse. The horse hit the lightning discharge. Collective farmer fell together with horse. Horse was killed. In collective farmer they were observed the short-term loss of consciousness, numbness and the loss of possibility to move legs and the right hand by which it held bridle and came into contact with its metallic part (see Fig. 213d).

Case 5. 1936, the station at Yepifan', settlement (eng. A. P. Belyakova's report/communication). Indoor of printing house of telephone set, are struck by the lightning of two people as a result of the transition of lightning from tree to telephone wires. About house at a distance 2 m, was located the poplar with a height/altitude of 10 m, the height/altitude of house, counting with the horse of roof - 5 m. Lightning hammered into poplar, it cut its top approximately 2.5 m in long, it split crust to the wiring point of telephone wires, it moved to wires, on them passed inside building, on walls and by-passed the people at the telephone. Simultaneously the lightning traversed the roof to walls.

end section.

Page 458.

The reason for damage/defeat was the absence of the necessary protection from the lightning of building itself and telephone wiring, moreover in immediate vicinity of building was located high tree that it is logical, it increased storm vulnerability (see Fig. 213e).

Case 6. 1958, Kolomna area, Moscow region (eng. P. A. Yurikova's report/communication and eng. A. N. Kuznetsov). During thunderstorm by direct strike were disintegrated two wooden supports of air lighting line. Electromagnetic thunderstorm waves penetrated in three houses of village, illuminated from this line. As a result of the penetration of thunderstorm waves into houses, occurred the lightning discharges with different consequences.

In the first house thunderstorm wave from the switch, arrange/located at height/altitude 1.5 m of floor level, through air gap into 10 cm passed to the metallic chain/network of hour-clock, hanging on wall, and further

through the air gap in 35-40 cm - to the stood on sex/floor sewing machine and into the earth/ground.

In the arranged/located on the contrary house thunderstorm wave from the receptacle, intended for the feed of radio receiver and arrange/located at height/altitude 1 m of sex/floor, through the air gap in 10 cm, passed to wooden strut (30 cm), also, from strut to the grounding of radio receiver. Fortunately, in both these cases the lightning discharge applied only some damages.

In the third house, arrange/located independently, at a distance 1 km of village and connected the same lighting line, the penetrated through air input/introduction thunderstorm wave from the switch, arrange/located about window, through the air gap in 50-60 cm, moved to sat of switch girl's head and mortally her it struck. Next to the girl sat another, who obtained the burn of legs. The third girl, who was being found at that torque/moment of opposite side of table, was reject/thrown into another end/lead of the room.

Case 7. 1960, Angarsk (report/communication of the correspondent of the newspaper "Proceedings"). At urban

stadium played the football players of local command/crews "Montazhnik" and "Torpedo". Was distinct weather, and the athletes and fans involved with the game did not notice that from behind the Sayany ominous clouds appeared. Were heard thunder unrolling/reelings. Spectators scattered, but football players continued game, following known rule "match takes place in any weather". When players were grouped at gates, in them hammered the lightning, as a result of which three athletes were struck, one of them - mortally.

It is hence clear, what value for safety during thunderstorm they have not only devices of lightning protection, but also people's behavior.

3. Need for thunderstorm protection.

National thunderstorm protection is of exceptional significance for the preservation of the life of workers and prevention of material damage.

The destructive action of lightning is possible with direct direct impact, through the drift of potential on overhead conductors or through induction, i.e., through effect on distance. As this follows of the given above cases of thunderstorm damage/defeats, and also from a series of others, the absence of storm protection or its unsatisfactory state can be the reason for the lethal injury of people, fires, decompositions, blasts.

Molniya selects the way of the smallest resistor/resistance, passing through the different metallic and other object/subjects with highest conductivity; in this case the conductivity of the medium through which passes the lightning discharge, is determined not only by the direct electrical resistance of the path of the current of lightning, but also by its self-induction, which has especially large value.

To this are explained the phenomena when lightning jumps from the specially laid wires of storm protection in the places of their sharp bends where as a result of curvatures is created the considerable self-induction, hindering the passage of the current of lightning. From this same point of view, becomes clear the phenomenon when

lightning strikes the lowest places, but possessing the smallest resistor/resistance of soil in comparison with higher places. Finally, it is understandable also, why lightning, after hammering into the tree, having high resistor/resistance of roots, it is moved through considerable air distances (several meters) to the adjacent houses which have better ground connection through the system of water pipe, channeling, etc.

The action of lightning is expressed in thermal or mechanical effect. An enormous quantity of heat, isolated by the current of lightning, and the phenomenon of the lightning discharge through air, when are near located easily ignited objects, serve as a reason for the onset of fires. Lightning strokes, besides fires, can also cause considerable mechanical damages; in this case the decomposition it will be the greater, the lesser the conductivity possesses the object which hit lightning stroke.

The greatest probability and the danger of mechanical decomposition represent those objects which possess high resistor/resistance to the passage of current and, being located highly in comparison with the surrounding object/subjects, are more subjected to lightning strokes as,

for example, brick factory and plant tubes (Fig. 214), tower, belfries, trees, etc. The destructive action of lightning especially visually is developed during the thunderstorm damages of trees.

On the contrary, on metallic object/subjects and the wires of a sufficient section of no destructive traces from the current of lightning it is detected. The observed sometimes cases of the extraction of the attachment of wires, their bending, apparently, are explained by the action of the electrodynamic forces of lightning, in the same way as this occurs in heavy electrical plants from short-circuit current. However, lightning discharges represent the greatest danger in the relation to fires.

Page 460.

Fig. 215, shows the decompositions, produced by lightning. These illustrations convincingly speak about the value which has properly carried out storm protection, and about the consequences of its absence.

4. Types of lightning protection (lightnings-arrestor).

For the preservation of buildings and installations from the destructive effect of the primary and secondary manifestations of lightning, must be provided for the corresponding protective measures. The totality of all actions, directed to this target/purpose, composes lightning protection.

For the characteristic of zone of protections of the different types of arrestors, are introduced the coefficients of the protection which determine the ratio of a radius of the shielded cone to the height/altitude of arrestor. In some practical cases with the impossibility to determine the coefficient of protection is introduced the coefficient of damage/defeat, which expresses distance ratio from the object damaged by thunderstorm discharge to the nearest arrestor or the object, which plays the role of arrestor, to their altitude difference.

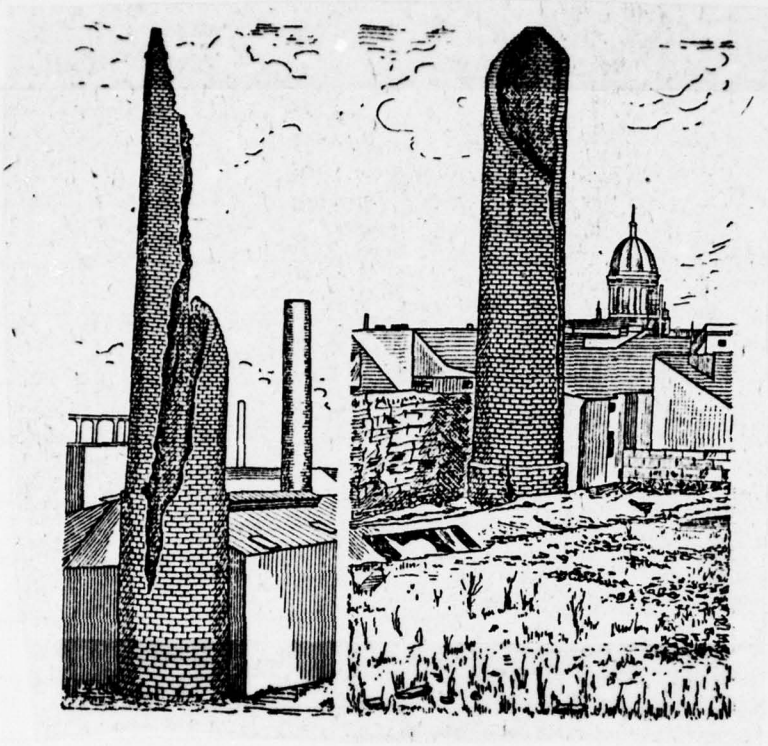


Fig. 214. Smokestacks, destroyed by lightning strike.

Page 461.

Antistorm protection, which has as its designation/purpose to receive lightning discharge - lightning - and to safely carry it off to ground, is more right to call lightning-arrestor. The existed previously determination "arrestor" is actually erroneous, since thunder is assigned

be it cannot; therefore in the examination of contemporary safety methods, they subsequently are called lightnings-arrestor. Thus, lightning-arrestor is the previously provided for and technically correctly carried out path for the current of lightning, thanks to which with the thunderstorm once a series lightning cannot produce decomposition or fire.

The fundamental contemporary types of lightning-arrestors for protection of buildings and installations from direct lightning discharges are: 1) divertor (bolt, rod) protection; 2) cable protection even 3) grid protection. Furthermore, there are intermediate types of lightning protection.

Any lightning-arrestor, independent of design, consists of three fundamental cell/elements: lightning receiver, current tap and grounding electrodes or groundings.

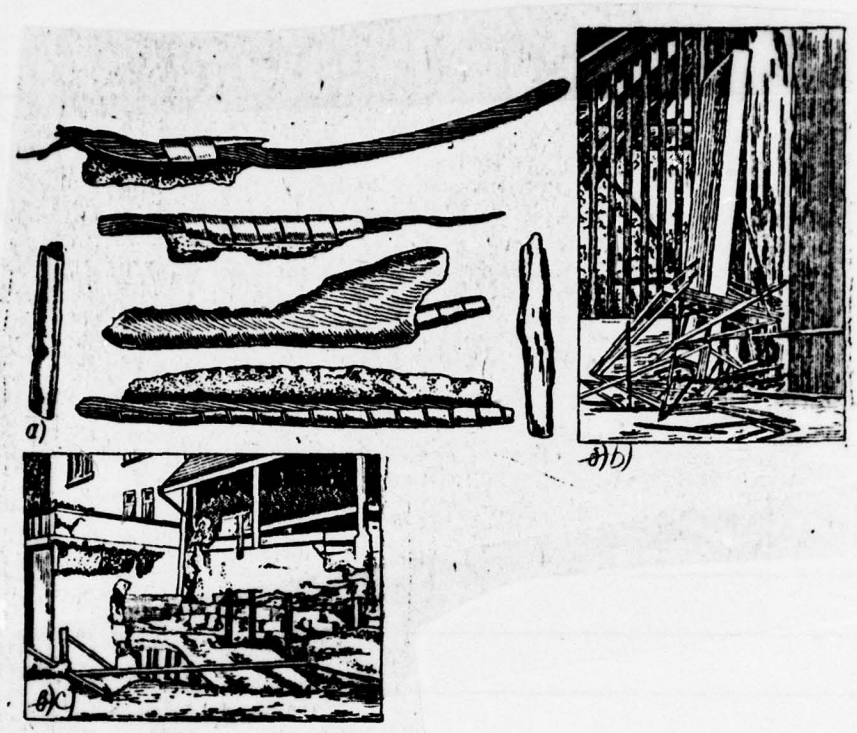


Fig. 215. Decompositions by lightning. a) lighting cable, b) wood work of building, c) concrete basin.

Page 463.

lightning collectors, or air terminals, are the highest part of the lightning conducting device and serve for the reception/procedure of lightning discharge - lightning - and

its supply to other parts of the lightning-protection device. Current taps - this is the cell/element of protection, connecting the lightning collector with grounding electrodes and intended for the safe removal/outlet of the current of lightning (lightning discharge), accepted by air terminal, into the grounding device. Grounding electrodes are itself the low part of safety device, placed into the earth/ground and which has as a goal to create it is possible smallest resistor/resistance between the current tap and the earth/ground, i.e., to support the satisfactory operation of lightning-arrestor as a whole. Before passing to the examination of the separate cell/elements of the lightnings-arrestor of systems indicated above, let us pause at the questions, which have the common value.

As material in the device of antistorm protection, apply mainly galvanized iron of different section and form depending on its designation/purpose: iron cables, band, rod iron, tubes, plate/slabs, grids, etc. Iron has advantage because of high melting point and relative to low cost/value. The application/use of copper is expedient, since in it is absent reluctance, but due to the high cost/value of copper from its wide use it is necessary to refuse.

The selection of the section of wires in the relation to the represented by them resistor/resistance does not play a role, because here decisive importance, as it is said above, has self-induction. For the conversion of electrical energy of lightning discharge into, the thermal resistance of wire has known positive value; therefore when selecting wire, they are guided first of all by temperature conditions, allow/assuming this section of the wire by which the current of lightning could not it melt. For this purpose they use either formulas indicated below calculation [1] or the establish/installed by practice data of the recommended sections of wires.

FOOTNOTE 1. Are undertaken from the book of I. S. Stekol'nikova "Molniya", publ. of the AS USSR, 1940. ENDFOOTNOTE.

If we accept the specific gravity/weight of copper $\gamma_м=9,83$ and the specific gravity/weight of iron $\gamma_м=7,86$, then the current of discharge, necessary for melting of wire, will be determined from the relationship/ratios:

for copper

$$I_м = 348\,000 \frac{q_м}{\sqrt{t}};$$

for the gland

$$I_м = 111\,000 \frac{q_м}{\sqrt{t}},$$

where q is a section of wire in мм²; t is time of the drop of the current of discharge from maximum value to 50o/o it into μs.

As follows from the available parameters of lightning, t can vary from 15 to 1000 μs and on the average can be accepted equal to 100 μs.

Page 463.

The section of all cell/elements of lightning-arrestor is selected not only according to calculation for the heating by the current of lightning, but simultaneously are considered the requirements for the greatest mechanical and chemical strength. The section of lightnings-arrestor must be not less than 50 мм². In the especially critical cases, and also in high-altitude buildings - section it is not less than 100 мм². The section of the iron wires of the current taps of those who were not branched - is not less

than 50 mm² and branched 25-35 mm². However, where it is possible to utilize copper wires, their section in comparison with iron must be decreased by half. The rapidly changing currents of lightning discharge cannot penetrate inside wires, but they are distributed over their surface. Therefore it follows instead of the massive wires, when this is possible, to apply multiple by galvanized iron cables, since with just one section the surface of cable is considerably more. In this respect massive ribbon conductors one should prefer to massive circular conductors.

The connections of the individual parts of the lightning conducting device must be completely reliable and provide continuity of an entire shielding system as a whole, otherwise lightning can deviate from the path designated by it, and in the place of disruption, will occur spark discharge with all its consequences for the shielded installation: in the place of jumping of discharges, the wire to melt, will be broken and will arise the fire hazard and damage/defeat.

For a durable and reliable contact it is necessary all the connections to produce with welding; only in such a case, when the execution of welding work is not represented

possible under these conditions, connection can be made by a screwing. With the realization of the contact by last/latter methods, it is necessary that the connection would be carried out overlapping and so that would be accepted the measures against the spontaneous weakening of nuts and bolts. Contact area must be not the less dual section of the combinable cell/elements. For lightning conducting device would be being long-lasting, it one should shield from chemical and mechanical damages. For the target/purpose of corrosion protection the iron, used for lightning conducting devices, should be well zinced. In the case of the simultaneous application/use of steel and copper of point of connection them it is necessary to shield from the penetration of moisture by the device of current conducting packing/seals to avoid electrolysis.

All the metallic parts of the installations, utilized as subsidiary with device lightnings-arrestor, it is necessary suchr well to shield from corrosion as a result of the effects of the atmosphere, cover/coating them with oil paint or asphalt varnish. Connections and to grounding electrodes, that are located in the earth/ground, besides zincing, should be cover/coated with asphalt varnish or resin for protection from the destructive effect of the

moisture of soil, but in the presence of acids in it - by asphalt varnish. Grounding electrodes themselves must not have the insulating coatings.

Page 464.

Protection from mechanical damages is provided by correct placement of the separate cell/elements of lightning conducting device at the shielded installations and their reliable attachment. The parts of the lightnings-arrestor, which are located on height/altitude 2.5 m, and at depth 20-30 cm of the earth's surface, must be shielded from possible mechanical damages. For this, are commonly used angular, channel or wooden coating.

The tube, used as enclosure/protection, creates this high resistor/resistance in the path of the current of lightning as a result of self-induction, that appears the danger of the change-over of lightning from current tap to the shielded installation. If there are metal enclosure/protections, it should be current tap connected also by them.

Divertor protection (rod).

Divertor, or is bolt, protection simplest. It is made in the form of the well grounded metallic or wooden rods (diverters) with those who were strengthened on them in the case of wooden rods lightning collector and the wires of leads. The pointed or made in the form of sphere upper part of the metallic rod serves as lightning collector, and rod itself - by a current tap. When diverter is made from tree, as lightning collector is applied the special iron core, strengthened to diverter and which is increased above it on 1-1.5 m (diameter its 25-50 mm). For a current tap are utilized the specially fastened wires of this section: for that which was not branched - 50 mm² (steel) even 50 mm² (copper), for that which was branched - 50 mm² (steel) even 25 mm² (copper).

Diverters were establish/installed for the shielded objective or on certain distance from it. The wooden supports of divertor protection have vital importance when diverters are placed directly for the most shielded objective (installation, building) and when it is necessary to prevent the possibility of the course of the current of

lightning through the body of the shielded object. This is reached by the device of current tap on the wooden support, which insulates lightning-arrestor from the shielded object.

During the setting up of the diverters of considerable height/altitude and at a distance from the shielded object then they make in the form of wooden columns either of metallic or in the form reinforced concrete masts (Fig. 216).

For the characteristic of zone of protections of diverters, besides the coefficients of protection, were introduced the angles of protection (angle between the height/altitude of cone and it generatrix); these angles were necessary for the characteristic of shielding properties during the simultaneous application/use of several diverters.

The analysis of thunderstorm damage/defeats, produced by I. S. Stekol'nikov, A. A. Akopyan and A. P. Belyakov, showed that in the majority of cases the coefficient of the damage was 1.5-2. Based on this, expedient it was in the especially critical cases of protection to recommend the coefficient of protection $K_3=1$ and the angle of protection

α = 45°.

Page 465.

For the reduction of prices of the device of lightning-arrestor the coefficient of protection increased to K_3 = 1.2-1.3 and respectively α = 50-52° (in less critical cases). During the use of several diverters, the zone of their protective action increases.

For the especially critical installations were recommended α = 45° and β = 50°, for less critical α = 50° and β = 55°.

As show investigations, the coefficient of protection depends on many conditions: the height/altitude of the standing of thunderclouds (the lower the cloud, the lesser the shielding space, created by lightning conductor); the relationship/ratio of the height/altitude of the shielded object and lightning-arrestor; the required degree of reliability of the arranged lightning protection.

This dependence is expressed by the following relationship/ratio:

$$K_3 = K_0 p A,$$

where K_0 - the high-altitude coefficient, which considers the height/altitude of the standing of cloud and determined by the following empirical formula:

$$K_0 = 5{,}89 \cdot \lg\left(1 + 0{,}086\frac{H}{h_0}\right),$$

where H is a height/altitude of the standing of thunderclouds in m;

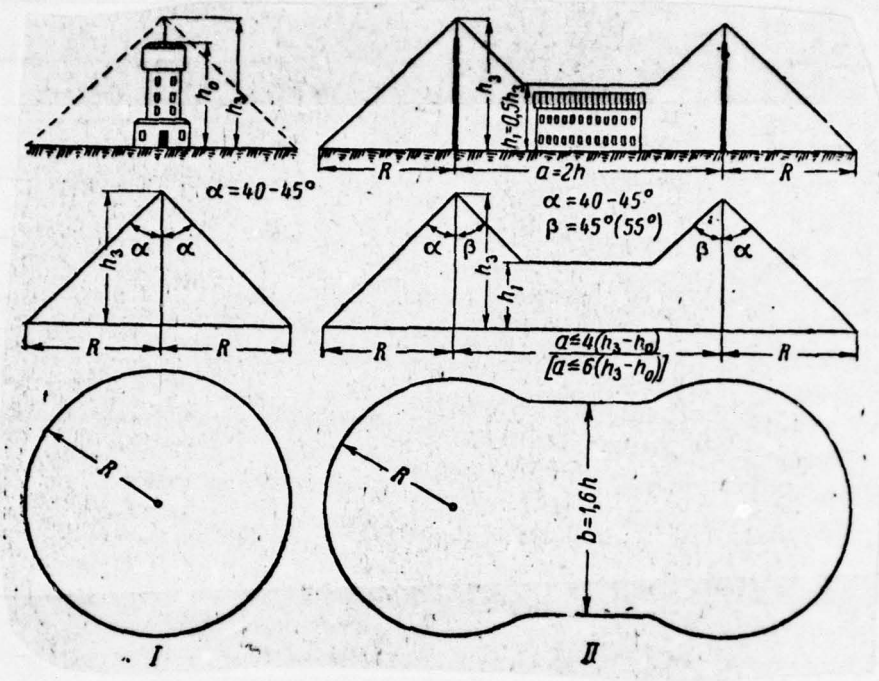


Fig. 216. Divertor (rod) lightning-arrestor and its characteristic. I - single lightning-arrestor, II - dual lightning-arrestor.

Page 466.

h_0 — a height/altitude of the shielded object in m; p - the boundary coefficient. Considered by the relationship/ratio of the height/altitudes of object and

lightning-arrestor and determined in the formula

$$p=1-0{,}218\frac{h_0}{h_3}-10^{11{,}74\frac{h_3}{h_0}-11{,}834},$$

(here h_3 is a height/altitude of lightning-arrestor); A - the coefficient of the reliability of protection, which can be accepted equal to 0.6.

For the case when lightning-arrestor has direct electrical connection with the shielded object (for example, with the protection of factory and plant chimney stacks and nonflammable installations), i.e., when is applied bolt protection, the coefficient of reliability can be taken as equal to 0.65. Knowing the coefficient of protection, it is easy to find the radius of protection:

$$r=K_3(h_3-h_0).$$

With the aid of the indicated formulas for the taken conditions H = 400 m and different values h_3 and h_0, are constructed the diagrams (Fig. 217 and 218), through which find a coefficient of protection and a radius of protection for divertor and bolt protection.

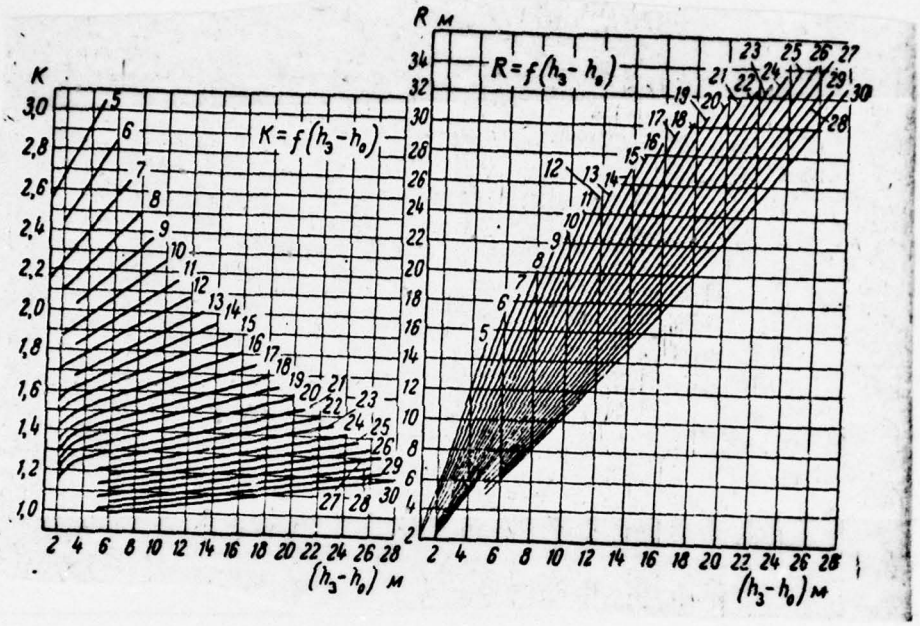


Fig. 217. Diagram for determining coefficient and radius of protection of diverter (numerals, designated directly of curves, indicate height/altitude of diverter above earth/ground in meters).

Page 467.

These diagrams make it possible to tentatively and rapidly determine the shielding properties of the lightnings-arrestor of the indicated types for specific conditions.

On the basis of the establish/installed by practice sizes of zone of protections, and also with the aid of the indicated diagrams was determined the corresponding quantity of diverters of the necessary height/altitude.

During the setting up of diverters, one should also consider the possibility of the transition of lightning from lightning-arrestor to the shielded installation. For the prevention of the similar phenomena, it is necessary that the distance between the lightning-arrestor and the shielded object would be not the less determined value.

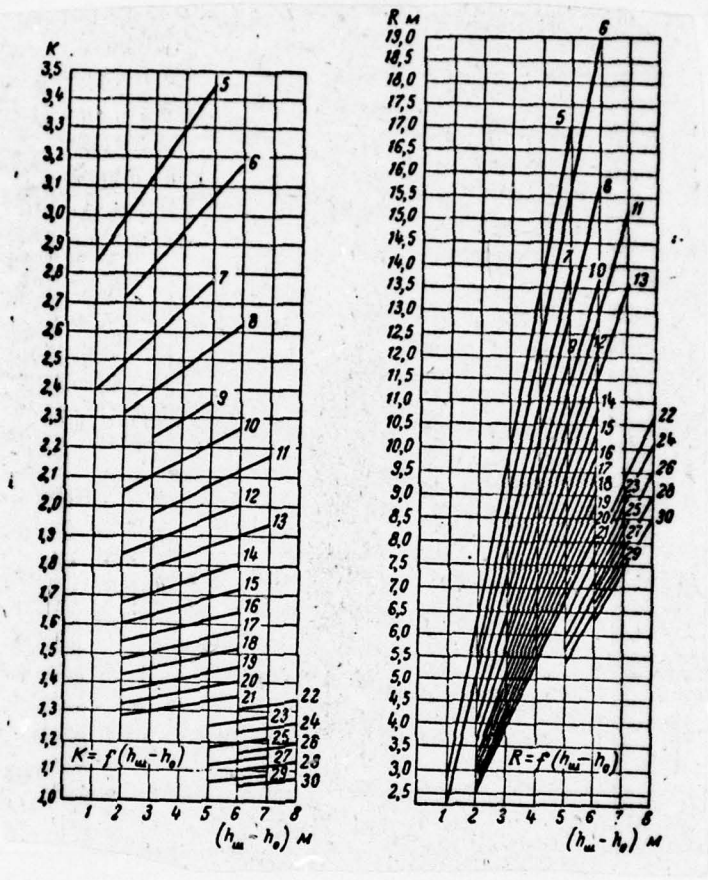


Fig. 218. Diagram for determining coefficient and radius of the protection of stub (numerals, designated directly of curves, indicate the height/altitude of probe above the earth/ground in meters.

This distance depends on the height/altitude of the shielded object h_0 and of earth resistance of lightning-arrestor R_i and previously it was determined from the formula

$$S \geq 24\left[1{,}5 - \frac{300 - R_i}{300 + R_i}\left(1{,}5 - \frac{h_0}{150}\right)\right],$$

where S - permissible distance from lightning-arrestor to the shielded installation in m;

R_i - earth resistance of lightning-arrestor in ohm;

h_0 - a height/altitude of installation in m.

For each assigned value R_i was obtained completely determined value S. The last formula is used for checking the impossibility of the transition of the discharge through soil. for this, instead of taken gradient of air, one should take the appropriate gradient of soil. In this case, it can happen, that depending on soil the last check will give the larger value of S, than preceding/previous.

Furthermore, it is necessary to consider the value of sufficient passages in accordance with the requirements for fire technology. In all cases where they must pass fire motor vehicles, the indicated distance must be not to

exchange 5-6 m.

Distance a among diverters, selected in accordance with height/altitude and the width of the shielded by them object, was indicated for the especially critical installations not more than $4(h_3-h_0)$, where h_3 is a height/altitude of diverter, h_0 is a height/altitude of protected object.

For the same target/purpose was intended the diagram (Fig. 219), constructed for different values R_i and h_0. On this diagram are shown the potentials, which appear in diverter during discharge.

To determine radius r - the zone of protection of a lightning rod - some investigators have proposed formulas which indicate the dependence of r on a number of factors.

Thus, for instance, peak indicated the law governing dependence of r on H and h_3:

$$r=\sqrt{2H-h_3},$$

where H is a height/altitude of the standing of cloud; h_3 is a height/altitude of lightning-arrestor.

A. A. Akopyan showed another dependence:

$$r_x=\frac{1,6}{1+\frac{h_x}{h_0}}(h_0-h_x)$$

where h_3 - the height/altitude of lightning-arrester; h_x - the height/altitude of the shielded object.

Page 469.

Antenna protection (cable).

As lightning collectors with antenna protection they utilize one or several wires, horizontally stretched above the shielded installation. Wires fasten on two specially for this the provided for supports. The section of wires must be not less than 70-100 mm² for gland and 50 mm² for copper (Fig. 220).

Supports are establish/installed directly for the most shielded objective or make in the form of the separate masts, adjustable at a distance and mechanically not connected with the shielded object. For insulation of current tap from the shielded object of the supports, adjustable for the objective, they must be made from

insulating material (tree). Zone of protection, created by the action of antenna lightning-arrestor, has a form of triangular prism. The angle of protection α is not more than 20-30°.

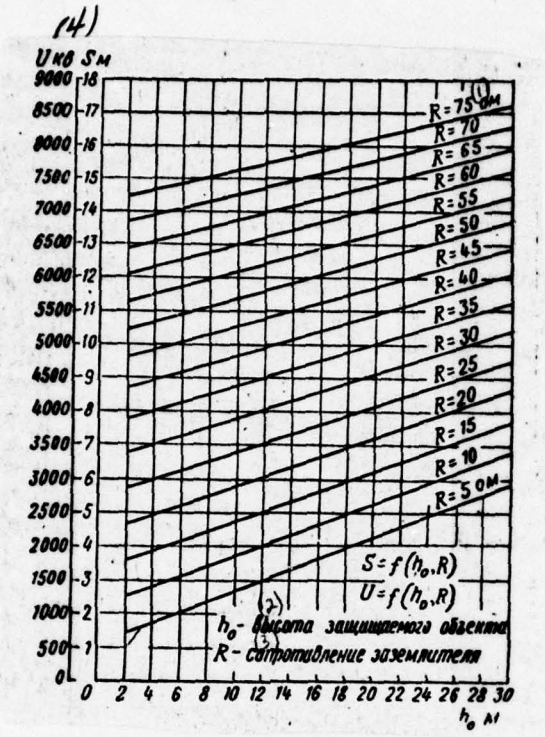


Fig. 219. Diagram for determining maximum potential in diverter and the smallest permissible distance from diverter to the shielded object.

Key: (1). ohm. (2). Height/altitude of the shielded object. (3). the resistor/resistance of grounding electrode. (4) kV.

Page 470.

The coefficient of the protection of antenna

lightning-arrestor was defined from the formula

$$K=K_0 pA,$$

as this it was made for diverter protection, with only difference from preceding/previous, consisting in the fact that the high-altitude coefficient K_0 in this case is determined from another formula, namely:

$$K_0=3{,}67\frac{\frac{H}{h_3}}{24{,}8+\frac{H}{h_3}},$$

where as before H is a height/altitude of the standing of thunderclouds in m; h_3 is a height/altitude of lightning-arrestor in m; h_0 is a height/altitude of the shielded object in m;

$$p=1-0{,}218\frac{h_0}{h_3}-10^{11{,}74\frac{h_0}{h_3}-11{,}834};$$

$$A=0{,}6.$$

Knowing K_3, it is easy to define zone of protection of the antenna lightning-arrestor:

$$L=K(h_3-h_0).$$

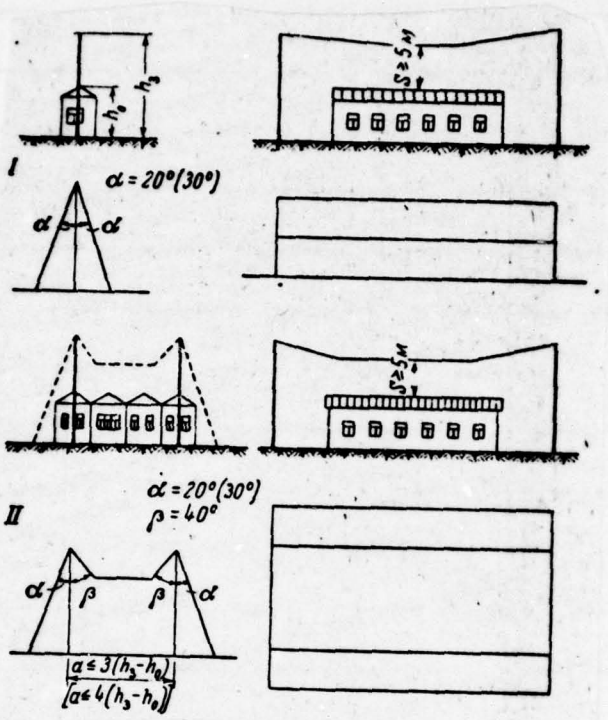


Fig. 220. Antenna lightning-arrestor and its characteristic. I - single lightning-arrestor, II - dual lightning-arrestor.

Page 471.

For convenience and the rapid determination of coefficients and zones of protection, just as for diverters, are constructed the diagrams, which indicate directly the value of coefficients and zones of protection depending on

the height/altitude of antenna and shielded object with H = 400 m (Fig. 221).

If protection is realize/accomplished with the aid of two antenna lightnings-arrestor, then the angles of protection are equal to: α = 20-25°, β = 45°.

With several wires in antenna lightning-arrestor, the shielding properties of the latter increase; therefore the separation of adjacent lightning-arrestor was allow/assumed that which was increased by 35o/o, i.e.,

$$a=1{,}35\cdot 2L=2{,}7L;$$

then zone of protection of this dual antenna lightning-arrestor will be equal to

$$L'=L+2{,}7L+L=4{,}7L_{\text{одной}},$$

where $L_{\text{одной}}$ is zone of protection, created by single antenna lightning-arrestor.

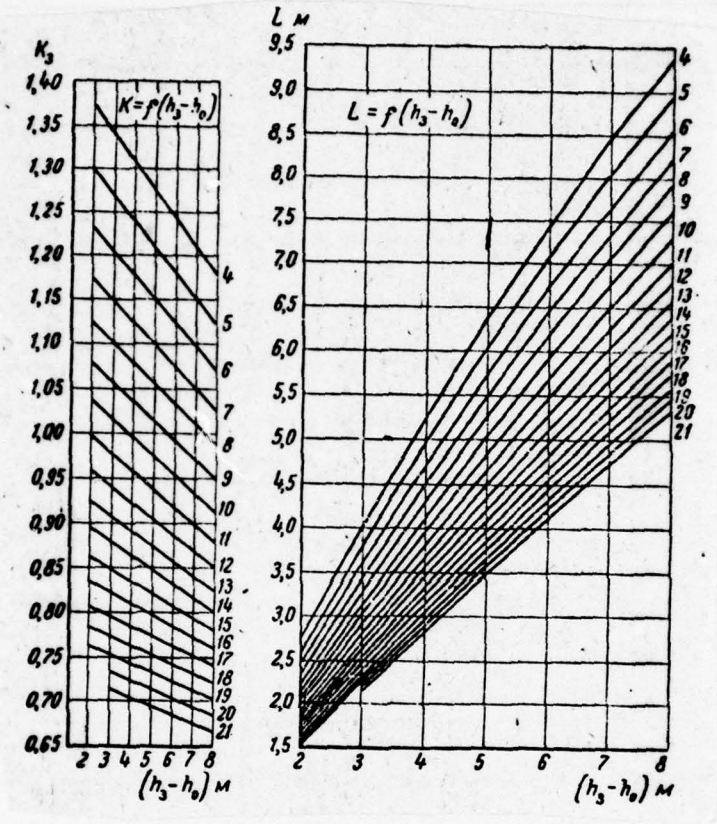


Fig. 221. Diagram for determining coefficient and zone of the protection of antenna (numerals, designated directly of curves, indicate the height/altitude of the lowest point of the antenna above the earth/ground in meters).

SUBJECT CODE 21560

Page 472.

In this case, distance a between two parallel lightnings-arrestor was allow/assumed: for the especially critical installations - are not more than $a = 2(h_3-h_0)$, for the less critical installations - are not more than $a = 3(h_3-h_0)$, where h_3 is a height/altitude of antenna lightning-arrestor, h_0 is a height/altitude of the shielded object.

In order to ensure the impossibility of lightning discharge into the shielded objects, the height of the antenna of lightnings-arrestor one should select in accordance with data indicated above of the coefficients of protection, shielding angles and the height/altitude of the shielded objects. To avoid the transition of discharge from lightning collector for the shielded objective, it was recommended so that the wires of antenna at the quite lowest point of their would be removed from the shielded object up to distance not less

$$S \geqslant 0{,}1\left(\frac{l_a}{2}+l_т\right) \quad [\text{м}]$$

where l_a - the length of the wires of antenna lightning collector in m;

$l_т$ - the length of the wires of each current tap in m.

This smallest permissible distance between the antenna wire and the shielded building can be defined by calculation as for divertor protection; it must be in any case not less than 5 m.

Grid protection.

This protection is actually Faraday's modified cage. It is arranged in the form of one or two wire gauze with the size/dimensions of cages from several meters to dozen centimeters (Fig. 222).

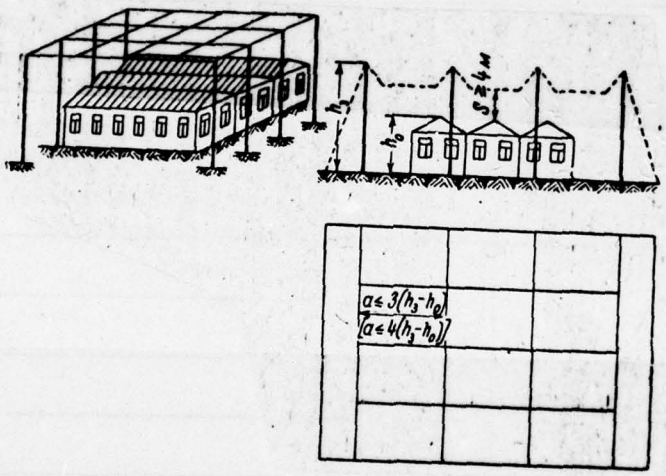


Fig. 222. Grid lightning-arrestor and its characteristic.

Page 473.

For the large grids, which have as assignment to

receive lightning discharge, the section of their wires must be not less than 50 mm² for iron and not less than 25 mm² for copper. Grid lightning collector are solidly fastened above the shielded object on the special supports, adjustable at a distance from the shielded object, or on wooden supports for the objective itself.

The grid protection the more ideal than the large surface of the shielded object it it encompasses, i.e., than more it approaches Faraday's cage and than it smaller. In this case the lightning-arrestor shields unit not only from direct lightning discharge, but also from its secondary manifestations through electrostatic induction.

The smallest permissible distance S between the grid and the shielded object

$$S \geq 0{,}8\left(\frac{l_n}{2}+l_т\right) \text{ [m]}$$

where l_n is length of the flight/span of grid in m; $l_т$ is length of each current tap in m.

Distance a between the parallel wires of grid was allow/assumed for the especially critical installations - are

not more than $a = 3(h_з - h_о)$;

where $h_з$ is a height/altitude of grid lightning-arrestor;

$h_о$ - the height/altitude of the shielded object.

Other methods of lightning protection.

Besides safety methods indicated above, when the possibility of the direct impact of lightning into building is not connected with the explosion hazard or fire, for equipment/device of lightning-arrestor, are utilized all the available on building metallic masses, the constructions, the conduit/manifolds, etc. For this purpose, all the metallic parts of the building - roof, beams, columns, drain pipes and so forth - connect up one whole and reliably they ground.

With this safety method, the roof plays the role of lightning collector, drain pipes and the metallic parts of the walls serve as current taps, but for a grounding are utilized water pipe or special grounding electrodes. In

certain cases lightning collectors are the wires of lightning-arrestor, laid on the most elevated parts of the roofing of the shielded building.

The indicated system of lightning protection is cheap and is found a use for the protection of the buildings, which are not the explosion hazard or fire and therefore they can safely perceive on themselves direct impact on the condition that all the metallic parts of the building are well connected and grounded. As an example of irrational lightning protection, previously was noted the system, which obtained in its propagation time, in particular, for the protection of dangerously explosive locations. This protection is spark arrestor with its arranged/located at nodal points beams of small rods - lightning collectors.

Page 474.

Grid is fastened directly during the roofing of the shielded building, it is not insulated from it and therefore it represents the determined danger for inflammable and dangerously explosive locations.

In the literature there are indications of the cases

of fires from lightning during the use of similar lightnings-arrestor. Being by very complex and way, this protection is unsuitable also for the less critical objects.

In the practice of the operation of lightning-protection equipment/devices in France, it is noted that the lightnings-arrestor of Franklin (rod) and of Faraday (cage) do not provide the reliable protection of buildings.

Under contemporary conditions is found a use as more advanced type, lightning-arrestor with radioactive ionizer (by driver) whose idea was known into 1914 more on the proposition of Stsillyard (French Academy of Sciences). Lightning-arrestor consists of the iron core whose one end/lead is connected with the earth/ground, and at other end/lead on insulating base, is located the metallic disk under which is placed the porcelain basin, covered with the indelible radioactive salt. Disk is connected with antenna. The potential of disk is equal to the potential of the layer of the surrounding atmosphere and it is positive with respect to rod. Repulsing the positive ions, isolated by radium salt, disk attract/tightens negative ions from rod and thus it serves as the driver of the ionization of air, preventing lightning discharge.

On existing knowledges, the radius of action of such lightnings-arrestor depends on the height/altitude of a point, quantity of radioactive salt, degree of the electrification of clouds it reaches several hundreds of meters.

The active part of the instrument is not subjected to the effects of the atmosphere, and the service life of this lightning-arrestor is not virtually limited.

5. Operating recommendations regarding equipment/device of lightning protection.

Examined types of lightnings-arrestor with their characteristics, which were being applied for many years, subsequently on the basis of conducting scientific investigations, supplementary research on the separate phenomena, connected with the thunderstorm also of the practical experience of the operation of lightning-protection equipment/devices were critically reexamined, which forced to

Match up in a new way the practical solution to the question concerning equipment/device of rational lightning protection.

The proposed by the separate authors formulas for the calculation of the zone of protection actually differ from each other and do not make it possible to accurately define the zones of protection; they can only orient in the direction of the solution to individual particular questions.

The taken in the USSR recommendations regarding equipment/device of lightning protection are connected with the need for very complex geometric constructions. Taking into account this fact, it was considered advisable of the zone of protection to determine by the simplified graphic method of their construction with the aid of straight lines and circumference.

Page 475.

With the accumulation of the systematized material on the operation of the existing lightning-protection equipment/devices and perfection/improvement of very methods

of experimental studies arose the need for refinement and correction of the existing lightning-protection equipment/devices with those, in order to create rational, virtually most reliable protection from lightning discharges.

Are shown below the used methods of graphic construction of the zones of protection for rod (earlier than divertor and bolt) lightnings-arrestor and cable, than earlier called antenna.

Rod lightning-arrestors.

Single. Height/altitude h_3 = 60 m.

The foundation of the zone of protection is circumference with radius r = 1.5h. The horizontal section of the zone of protection at the height/altitude of the shielded object h_x - is circle with radius of r_x (0.5 lengths of the shielded object).

If the height/altitude of object $h_x \leq 2/3 h_3$, that most frequently occurs in actuality, then it is necessary to

connect point, which is located on the axis of cone on height/altitude 0.8h from ground level, and point, which is located at ground level at a distance r = 1.5h (Fig. 223a).

For higher objects construct the supplementary straight line, which connects the apex/vertex of lightning-arrestor with the point of the ground-based surface, which delays behind its base at a distance r/2 = 0.75h (Fig. 233b).

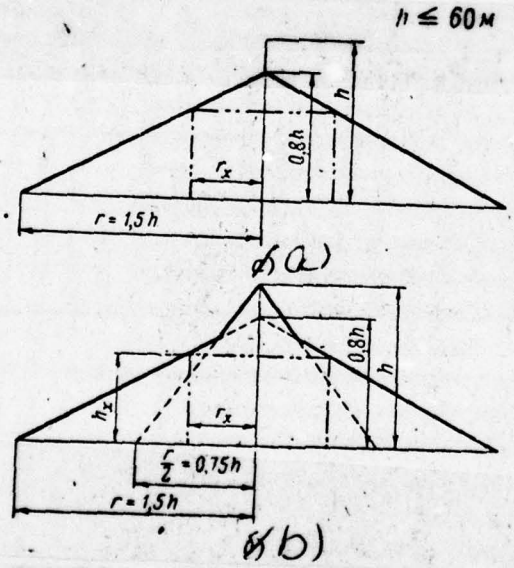


Fig. 223. Graphic construction of zone of protection of rod lightning-arrestor.

Page 476.

The determination of a radius is conducted by the formulas:

1) under conditions when $0<h_x\leqslant{}^2/_3h_a$, $r_x=1{,}25K\ (h_a-1{,}25h_x)$; (Fig. 224a);

2) under conditions when ${}^2/_3h_a<h_x\leqslant h_a$, $r_x=0{,}625K\ (h_a-h_x)$.

With rod lightning-conducting K = 1.2.

Dual. The layout of the zone of the protection of dual rod lightning-arrestor with height/altitude $h_a \leqslant 60$ m and the distance between lightning-arrestors is shown in Fig. 224.

End-type regions are represented by the zone of the protection of single rod lightnings-arrestor. The middle part of the zone is limited on top by the circumference, passing through the apex/vertexes of lightning-arrestors and

the least height/altitude of the zone of the protection which in turn, is determined by the forsulas

$$h_0 = 4h_s - \sqrt{9h_s^2 + 0,25a^2}.$$

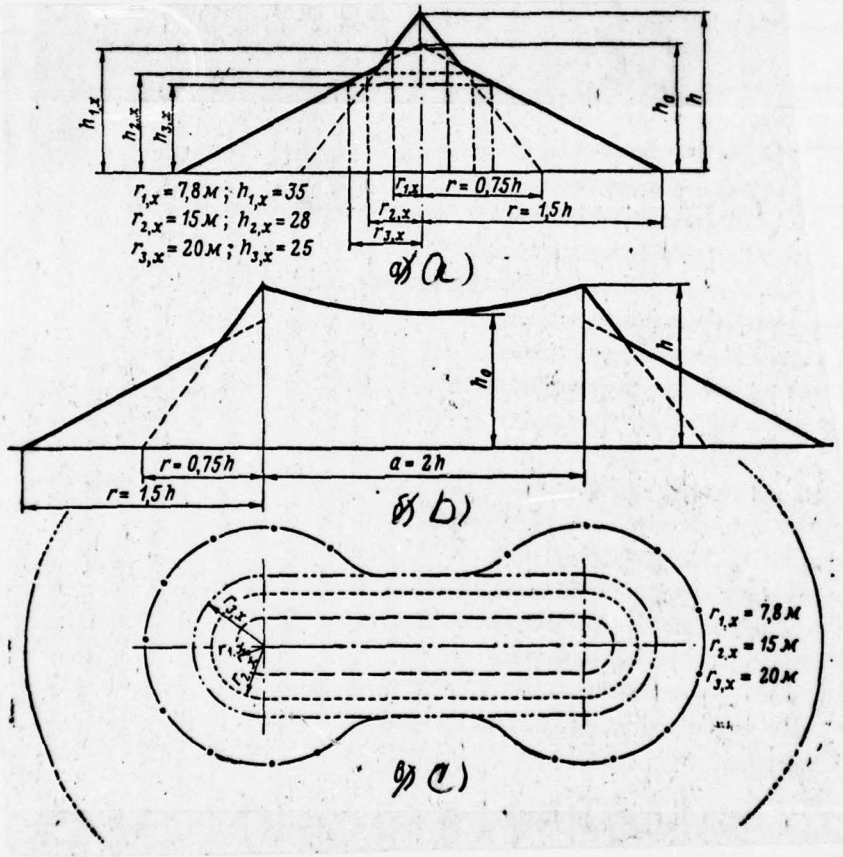


Fig. 224. Rod dual lightning-arrester.

Page 477.

But if are known the height/altitude of lightning-arrestor and the distance between lightnings-arrestor a, then it is possible to determine the necessary by the conditions of safety height/altitude of the lightning-arrestor

$$h_3 = 0{,}571 h_0 + \sqrt{0{,}183 h_0^2 + 0{,}0357 a^2}.$$

As a result of comparison and research on these various work, is recommended the following dependence between the height/altitude of lightnings-arrestor h_3, the smallest height/altitude of the zone of protection h_0 and the distance between the lightnings-arrestor:

$$\left(\frac{a}{2h_0}\right)^2 = \left(K_1 - \frac{h_0}{h_3}\right)\left(1 - \frac{h_0}{h_3}\right),$$

where for the dual rod lightning-arrestor K_1 = 7.

At values a/h_3 > 5.3 circumference, which limits from above the surface of the zone of protection, it will touch the line, which connects the foundations of lightning collectors: h_0 = 0; r_0 = 0. At value a/h = 6, dual rod

lightning-arrestor operates as two single rod lightning conductors.

Cable lightning-arrestors.

For determining the zone of the protection of cable lightning-arrestor, are applied the same methods of graphic construction, as during the definition of the zone of the protection of single rod lightning-arrestor, with only difference in the fact that the radius of a circle of the zone of the protection

$$r=1{,}25h_з$$ instead of $$r=1{,}5h_з.$$

The middle part of the zone of protection is limited to circumference, is passing through the axle/axes of cables and the point, which determines smallest height of the zone of protection h_0. This height/altitude is determined from the formula

$$h_0=3h_з-\sqrt{4h_з^2+0{,}25a^2}.$$

If are known h_0 and a, then can be determined the

necessary height/altitude of lightning collector, i.e., the height/altitude of the suspension of cable and supports:

$$h_3 = 0{,}6h_0 + \sqrt{0{,}16h_0^2 + 0{,}05a^2}.$$

In this case, the height/altitude of the supports on which is suspended the cable, is selected taking into account the deflection of cable.

With relationship/ratio $a/h_3 = 4.4$, circumference will touch ground level, i.e., $h_0 = 0$, with $a/h_3 = 5$ interaction of cables disappears.

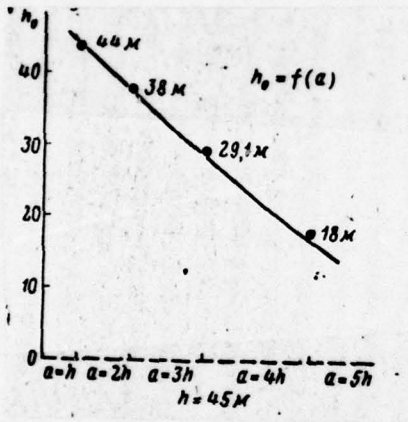


Fig. 255. Dependence of smallest height/altitude h_0 of zone of protection on distance between lightnings-arrestor a.

Page 478.

Object, which is found on territory with the arranged/located on it several lightnings-arrestor, is

shielded from lightning discharges, if diameter of a circle, passing through the apex/vertexes of lightnings-arrestor, does not exceed octuple active height/altitude, i.e.,

$$D \leqslant 8(h_3 - h_x).$$

To avoid the overlap by lightning from lightning-arrestor for the shielded objective, it is necessary between them to maintain the determined distances, on the basis of the value of the potential, which appears during lightning discharge on lightning-arrestor, and the permissible electric intensity of medium.

During lightning discharge, with the course of the current of lightning through the lightning-arrestor, on the latter appears the very high potential, which is caused by a voltage drop across the effective resistance of the grounding of lightning-arrestor (pulse resistor/resistance) and on inductive reactance of current taps. With respect to this potential on lightning-arrestor can be represented by the following expression:

$$U_м = I_м R_з + \frac{dI_м}{dt} L \text{ [V]}$$

where $U_м$ - potential (stress earth referenced) on lightning-arrestor;

$I_м$ - a current of lightning in kA (100-150 kA);

$\frac{dI}{dt}$ - a rate of the increase of the current of lightning, equal to 30 k/s;

L - inductance of current taps (from the calculation of specific inductance in 1.7 mH on 1 lin. m. of current taps and length of current taps in l m).

After accepting the current of lightning $I_м$ in 150 kA and average electric intensity in air E = 500 kV/m, finds smallest, permissible through conditions of safety, the distance between the lightning-arrestor and the shielded object:

$$S_в \geq \frac{U_м}{E_в} = \frac{I_м R_з + \frac{dI}{dt} L}{500} = \frac{150 R_з + 30 \cdot 1,7 l}{500} = 0,3 R_з + 0,1 l.$$

To avoid overlap in the earth/ground in the case of lightning discharge from the grounding electrodes of lightning-arrestor to underground communications, the structural/design parts of the buildings, also must be provided the sufficient distances

$$S_0 \geq \frac{I_M R_1}{E_3} \geq \frac{150 R_1}{300} = 0{,}5 R_1,$$

where E_3 - average strength of electric field in the earth/ground is equal to 300 kV/m.

Page 479.

6. Hints on equipment/device of lightning protection.

All the examined types of lightning protection are essentially characterized by only lightning collectors; in relation current tap and groundings they do not differ from each other and are subordinated to general for them requirements.

Current taps. With equipment/device of current taps, one should ensure a sufficient section of their wires. In the practice of the application/use of lightning conducting equipment/devices, repeatedly were observed the cases not only of the melting of wires, but also their complete evaporation under the action of heat from the current of

lightning. As already mentioned above, when selecting section, one should proceed not only from the value of the permissible heating of wire by the current of lightning, but also from its necessary mechanical strength and the possibility of its corrosion.

Furthermore, it is necessary to consider a change in the length of the wire of current tap as a result of the temperature phenomena. So that the current tap could be expanded and be presssed with alternations in the temperature, one should with the attachment of current taps not stretch them and and what is more - one should place special compensators. The attachment of current taps must be sufficiently reliable; for this are applied the supports of various forms. If building is not dangerous in the relation to fire or blast, wire of current taps for protection from mechanical damages is expedient to place in the places of those who were provided for for drain pipes, or in other places, sufficiently shielded. In this case, the wires are arranged at a distance not nearer than 0.1 m of stone walls even 0.2-0.3 m of other. In the remaining cases when locations can represent the explosion hazard or fire, the smallest permissible distances calculate also according to diagrams.

The current taps it is necessary to remove as much as possible from all sides of the shielded installation at a distance not more than 15-20 m of each other. In all cases when there is no fire hazard or blast, one should utilize as current tap continually available on installation of metal constructions - column, farm/trusses, drain pipes, etc.

In order to create lightning path with the smallest resistor/resistance, it is necessary current tap to conduct not only according to the shortest path, but to mainly avoid angles, sharp rotations, making smooth transitions from the current taps, arrange/located on roof, to wall current taps and further - to grounding electrodes. If necessary for the bendings of wire, they must be laid with the largest possible radius; if this is does not made, then is lightning, encountering high resistor/resistance in bendings and selecting to itself the way of the smallest resistor/resistance, it can easily jump to the shielded installation. For a decrease in the resistor/resistance, one should apply wires with larger surface, i.e., multiple instead of the massive and rectangular instead of the circular.

circular.

Page 480.

Grounds. For all examined systems of lightning protection, the correct equipment/device of grounding has extremely important value. Grounding electrodes together with the wires, which connect them with current taps, are that basic part of the lightning protection whose assignment consists not only of safe to abstract/remove the current of lightning into the earth/ground, but also to provide its even distribution in the earth/ground. For this, it is necessary that contact resistance of the grounding of lightning conducting equipment/device would be smallest of all contact resistance which can turn out to be near; otherwise lightning-arrestor during lightning discharge it will not fulfill their problem. So, if contact resistance of the grounding electrodes of lightning-arrestor is great in comparison with the resistor/resistance of the natural grounding electrodes of the nearest objects, then lightning discharge can occur not into lightning-arrestor, as this probably but it is direct into those located near the installation, which have smaller contact resistance, i.e., lightning protection will actually not able shield from

lightning. As this follows of the given above calculation formulas, the higher pulse earth resistance $R_и$, the the more distance is required between the lightning-arrestor and the shielded object, i.e., in other words, facts is more complex and more expensive the fulfillment of entire lightning-arrestor as a whole. On the other hand, the higher contact resistance of the grounding electrodes of lightning-arrestor, the greater the stress directly in soil and on grounding electrodes during the lightning discharge and in the presence of the greater danger undergone people, who are located near.

If we the smallest value of the current of lightning accept into 10000 A. and the resistor/resistance to spreading of grounding electrodes in 20. ohm, then the stress, which appears directly in the place of the transition of terrestrial current, will be 200 thous. V (with respect to the sufficiently removed point of the earth's surface potential of which can be taken as equal to zero). Thus, is created the danger of damage/defeat near the place of the grounding of lightning-arrestor as a result of step-type stresses.

Through the indicated reason to be located during

thunderstorm about the grounding electrodes of lightning-arrestor at a distance are nearer than 10 m dangerously. It is necessary to apply special means for the steadier drop of potential with the aid of wire gauze from the bands, connected with grounding electrodes into one system. Therefore with equipment/device of thunderstorm protection, it is necessary to focus most serious attention on the fact that grounding electrodes had smallest contact resistance to spreading in comparison with the grounding electrodes of the nearest objects.

One should distinguish artificial and natural grounding electrodes. As the artificial grounding electrodes of lightnings-arrestor, are applied iron tubes, the rails, the plates, the grids; as natural grounding electrodes can be used the water pipes, sewers, pumps, the pits and other metallic object/subjects, laid in soil and which have contact with well conducting layers of the earth/ground or with ground water.

Page 481.

With equipment/device of the grounding of lightnings-arrestor in the locations, not dangerous in the

relation to blast or fire, one should first of all utilize natural grounding electrodes; for this, of course, is required the resolution of the organization in conduct of which is found the operation of this installation. In the case of the impossibility to utilize natural grounding electrodes and the needs for arranging artificial is most better used the gas tubes with length l = 2.5-3 m, thickness Δ 3.5 mm, ϕ 50 mm; plate/slabs - 50 x 100 cm with thickness 3 mm; grid are 1 m (from the steel wires with a diameter of 8 mm).

The grounding electrodes, intended for the grounding of lightnings-arrestor and laid around the shielded buildings and installations, must gear into one system in the form of ring or semirings. For the elimination of inductive reactance, which appears during the passage of the current of lightning, the tubes, arrange/located in circumference, must be connected by circumference and by two mutually perpendicular diameters. During arrangement/permutation on the rectangular outline/contour of tube, they must be connected on outline/contour and then along two diagonals. The grounding equipment/device fulfills usually by such shape, as this is made for equipment/device of the working or shielding grounding of electrical installations.

When the resistor/resistance of the soil is very great and there are no natural grounding electrodes, for a decrease in the resistor/resistance of grounding electrodes, are applied surface grounding electrodes in the form of iron strips or bands by section 4 x 40 mm, packed into depth 0.3-0.4 m and in the appropriate distance from the shielded installation. When appears difficulty with equipment/device of the grounding of one or the other current tap to the common grounding equipment/device of lightning-arrestor, each of them can have independent grounding in the form of iron tubes or surface grounding electrodes.

7. Protection from the secondary manifestations of Molniya.

Systems examined above of lightnings-arrestor are intended for the protection of the various kinds of installations and buildings from decompositions in the presence of the direct effect of lightning. The destroying action of lightning is possible not only with direct

inpacts; it can also occur, also, through induction - electrostatic and electromagnetic.

Electrostatic induction. So he is called the phenomenon of the onset of the electric charges through effect at a distance. If thunderstorm cloud with the determined electric charge (for example, negative) is located above any object, insufficiently well grounded, then on the latter through induction appear the electric charges of the dissimilar signs, equal to the charges of cloud. The charges, arrange/located nearer to cloud, will have the dissimilar sign, in this case plus, and most distant charges - minus sign. The dissimilar electric charges are attract/tightened, and analogous/similar are repulsed; therefore negative charges for the objective, analogous/similar with charge clouds, as not not connected with it, depart to the earth/ground.

Page 482.

After the lightning discharge, which occurs instantly, for the objective, if the latter does not have sufficiently good ground connection, positive charges will not have time to leave into the earth/ground ii, remaining for a while for the objective, they will create a potential difference

between the object and the earth/ground; in other words, object will render/show under stress with respect to the earth/ground and with a sufficient stress level between the object and the earth/ground will occur spark discharge. This appearance of stress is possible on the metallic roof of stone or wooden building with respect to the water-conducting system or other grounded object/subjects of this building (Fig. 226).

The stress in buildings can arise through electrostatic induction even when charges are induced outside building, for example for air electric wiring, and are recorded in it on electric wires. The onset of similar stresses and, their as consequence, sparking represent terrible danger for explosion- and inflammable locations. In the literature there are indications that the sparking between the current-conducting object/subjects through induction is possible with sufficiently large distances.

It is obvious that if the object, on which can be located the electric charges, is well grounded, no danger of sparking arise can, since after discharge of cloud all the remaining for the objective electric charges through the grounding will leave into the earth/ground, without creating

with respect to it a dangerous potential difference. Therefore for protection fire- and dangerously explosive installations and buildings from the sparking, which appears as a result of electrostatic induction, it is necessary all the current-conducting parts of the shielded object to reliably ground and not to allow/assume unit in the building of the large extended metallic object/subjects, isolate/insulated from the earth/ground. Then under the condition of grounding the appearing on these object/subjects through electrostatic induction charges will be easily and rapidly abstract/removed into the earth/ground and will not create that potential difference with respect to the earth/ground with which are possible the spark discharges. But, as it shows practitioner, even in the well grounded conducting parts of the building and the absence in it of the metallic isolated/insulated object/subjects is not eliminated the possibility of the destructive action of lightning through the electromagnetic induction.

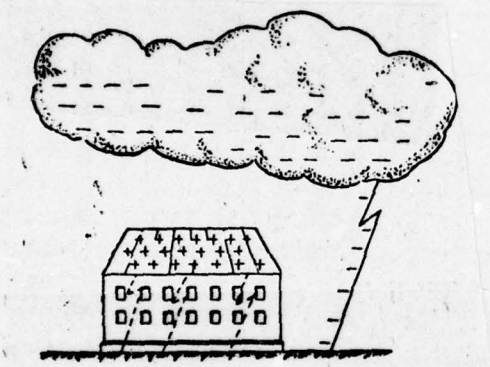


Fig. 226. Secondary manifestation of lightning discharge. Electrostatic induction.

Page 483.

The grounding equipment/devices, intended for protection from the discharges of static electricity, simultaneously serve for protection from the secondary manifestations of

the lightning through electrostatic induction, if the resistor/resistance of grounding electrodes does not exceed 5 ohm in the case of the objects of the first category and not less than 10 ohm - in the case of the objects of the second category.

For protection from static electricity and the secondary manifestations of lightning, is allow/assumed the use of the grounding equipment/devices of electrical devices, if their resistor/resistance does not exceed those who were indicated above.

For protection from the secondary manifestations of the lightning of equipment and installations, which are located under metallic roof, the latter must be grounded through each 15 m on the perimeter of building. In this case the connections of the equipment, communications and other object/subjects within installation to grounding electrodes is not required.

But if simultaneously appears the need for protection from the static electricity, generated under conditions of work, then the supplementary grounding of all metallic objects, contained location, installation with the grounded

metallic roof is compulsory.

Electromagnetic induction. If in shielded building the conduit/manifolds, cables, the constructions of grounding electrodes form the closed outline/contour and if this outline/contour by the cross lines of the magnetic field, which appears around the current of lightning, then in outline/contour is excited electromotive force, which in turn, creates current in the indicated outline/contour (Fig. 227).

The appearing current in the places of the poor contact of outline/contour can cause considerable overheating and create the danger of the inflammation of combustible substances, which are located hereabout. Furthermore, electromotive force of the electromagnetic induction which in value can reach several ten thousands of volt, under known conditions can turn out to be sufficient for the formation of the spark discharge through the air gaps between the loosely contacted parts of this outline/contour and create the explosion hazard and fire. The protection of installations from the indicated danger by enclosure/protection by wire gauze does not reach target/purpose.

For protection from the sparking, which appears through the electromagnetic induction, it is necessary all the extended metallic object/subjects, which fall in the field of the current of lightning, to make in the form of the closed outline/contours, since only in this case it is possible to avoid the sparking between the separate current-conducting systems.

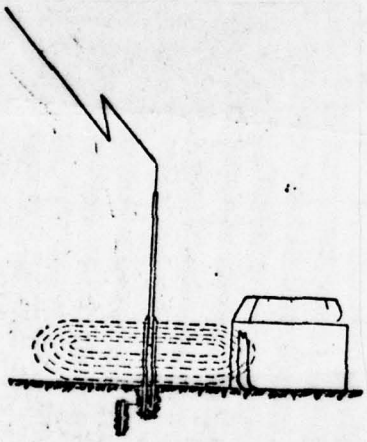


Fig. 227. Secondary manifestation of lightning discharge. Electromagnetic induction.

For example, sparking can appear between the sheathings of the in parallel laid cables. For this prevention/warning between the in parallel going current-conducting systems, one should make special metallic cross connections.

For the creation of the closed outline/contour and prevention of sparking, it is necessary to connect by cross connections all in parallel going conduit/manifolds, arrange/located in shops, piers, channels, at a distance to 10 cm from each other; cross connections must be establish/installed through each 20 m.

The conduit/manifolds, which intersect and converging to 10 cm, independent of their assignment, affiliation/accessory, they must be in the places of approach and intersections are connected between themselves cross connections. If conduit/manifolds are located at a distance to 10 cm from metallic staircases, area/sites, constructions, they must be connected to them by cross connections (Fig. 228).

Besides the secondary manifestations of lightning as a result of electrostatic and electromagnetic inductions, there is a danger of the drift of high potential into installations, which are located at a distance from

lightning-arrestor, through metal cable sheathing. When occurs lightning discharge, in the place of the transition of terrestrial current, appears high potential. If is near arrange/located cable, then metal cable sheathing will render/show under high potential; the latter thus can be carried into the location, removed from lightning-arrestor, and, furthermore, cable can prove to be opened. In order to avoid the indicated phenomena, it is necessary to maintain/withstand the determined distances between the grounding electrodes of lightning-arrestor and cables.

These distances must correspond to the distance, calculated by the formula

$$S=0,5R_i\ [м],$$

where R_i is pulse resistor/resistance of the grounding equipment/device of lightning-arrestor.

Cables and conduit/manifolds in the places of entrance must be grounded.

The same one should say, also, about equipment/device of the shielding grounding of electrical plants.

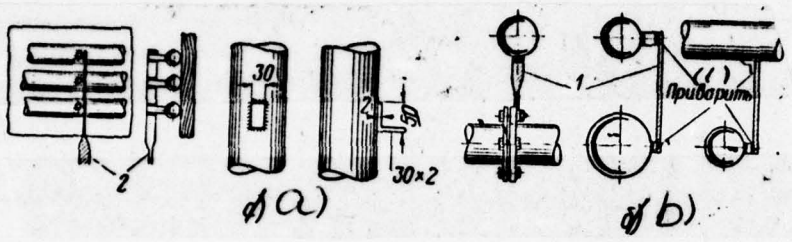


Fig. 228. Equipment/device of cross connections on conduit/manifolds. a) the attachment of cross connections by the means of welded lugs, b) the attachment of the cross connections on of conduit/manifold, 1 - strip steel 25 x 2 mm, 2 is a current tap 25 x 4 mm to grounding electrode.

Key: (1). To weld.

Page 485.

For the prevention/warning of the danger of the incidence/impingement of the high potential of lightning discharge to the system of the shielding grounding of

electrical devices, it is necessary that the grounding electrodes of lightning-arrestor would be at a sufficient distance from each other. As the smallest permissible distance, by analogy with that which was indicated is above, one should establish/install 10 m.

Drift of dangerous potential on overhead conductors into buildings. This phenomenon represents the greatest danger; therefore it requires serious attention, especially in the rural and summer-resort localities where not protected by the shadowing of the surrounding structures aerial lines and the connected with them buildings are most subjected to lightning discharges.

To prevent/warn the danger of the drift of high potential is necessary by equipment/device of the grounding of the hangers of the insulators of entrances and of aerial lines on the nearest two-three supports. Earth resistance must be 10 ohm.

Lightning discharge into antenna, which is located outdoors, can cause the drift of potential into location. This creates direct/straight threat for the life of people, who are located indoor, and the fire hazard and mechanical

decompositions.

For the prevention/warning of such drifts along the struts, which support antenna, it is necessary to lay the wire whose one end/lead must gear with metallic roof, and another must be arrange/located at a distance 10-15 mm from the cable of antenna.

In location itself the wire, which goes from antenna to radio receiver, must be connected up through the switch, which makes it possible either to include/connect receiver to antenna or to include/connect antenna for grounding.

This switching is the necessary action of safety.

The use of radio receiver and television set during thunderstorm is inadmissible.

Page 520.
References.

Часть первая. Электрический ток

1. Золотарев Г. Л., Энергетика мира, изд. «Знание», 1959.
2. Королькова В. И., Электротравматизм и борьба с ним в промышленности. Докл. на Всесоюзной конференции ВНИТОЭ по борьбе с электротравматизмом, 1954.
3. Елинек С., Несчастные случаи от электричества, Перев. с немецкого, 1927.
4. Вигдорчик Н. А., Электропатология, изд. Института гигиены труда и профзаболеваний Ленгорздравотдела, 1940.
5. Габай А. В., Повреждения от электрического тока, Б. Запорожье, 1938.
6. Троицкая А. Д., Электротравма кожи, 1947.
7. Сыренский Н. Н. и Сапаров М. Я., Об изучении электротравм, «Врачебное дело», 1948, № 1.
8. Каплан А. Д., Поражения электрическим током и молнией, Медгиз, 1951.
9. Каплан А. Д., Основы травматологии (разд. «Повреждения от электрического тока»), Медгиз, 1952.
10. Мейер Г., Основные положения систематики электротравм. Meyer G., Deutsch Elektrotechnik, 1956, 10, № 9.
11. Петров И. Р., О влиянии на организм электрического тока. В кн. «Электротравматизм и борьба с ним в промышленности», изд. Ленинградского института Охраны Труда ВЦСПС, 1936.
12. Либих С. Ф. и Каневский И. А., О сравнительном действии на организм переменного тока низких частот, «Гигиена труда и техника безопасности», 1935, № 5.
13. The experiments of Weber «The Electrical Revieu», 1936, July.
14. Bonnardel Ret Neoussikine B. Etude sur la conductibilite electrique du corps humain «Le Travail humain», 1937, mars, Paris.
15. Dalziel C., Lassen B., Effects of Electric Current of men «News and Engineering», 1941, 50, № 22.
16. Konvenhoven Fellow AIEE «Effects of Electricity on the Humain Body, «Electrical Engineering», 1949, March.
17. Швейсхеймер, Причина смерти от электричества. «Elektro und Radiotechnik», 1955, 10, № 23.
18. Шнейдер, Несчастные случаи от электричества и физиологическое действие тока, «Elektrotechnische Zeitschrift», 1956 A, 77, № 4.
19. Killinger I., О действии постоянного тока на человека, «Elektrotechnische Zeitschrift», 1956, B. 8, № 3.
20. Dalziel C., Effects of electric chock on men «IRE» Frans., med., Electronics, 1956, July.
21. Adam, Смерть от электрического тока, «Sicherheit Bergbau», 1958, 4, № 1, 2,3.
22. Синев П. И., Основы техники безопасности, Профиздат, 1932.
23. Пресс С. А., Электрические установки и техника безопасности, Госгрудиздат, 1930.

Page 521.

24. Копытов Н., Условия безопасности в кабельных фабрично-заводских сетях низкого напряжения, «Электричество», 1931, № 5.
25. Королькова В. И., Проблема заземления в установках 380/220 *в*, «Электричество», 1937, № 2.
26. Лобль О., *Заземление, зануление, защитное отключение*, 1937.
27. Лурье А. И., Испытания заземляющих устройств электрических установок, Госэнергоиздат, 1951.
28. Mores E., Меры безопасности от случайного перехода напряжения на доступные металлические части, «Journal electriciens», 1955, № 312.
29. Найфельд М. Р., Защитные заземления в электротехнических установках, Госэнергоиздат, 1959.
30. Цапенко Е. Ф., Условия безопасной эксплуатации сетей с изолированной нейтралью, «Электричество», 1958, № 4.
31. Манойлов В. Е., Глазенап М. С., Григорьев В. Т., Выбор режима нейтрали трансформатора сети низкого напряжения «Промышленная энергетика», 1957, № 2.
32. Гильберт, Выключатели с контролем утечки тока на землю «Electrical Times», 1956, 130, № 3397.
33. Кларк Ф., Безопасное пользование электричеством, «Britisch Journal Industrial Safety», 1957, 4, № 40.
34. Zandra B., Защитные кожухи и покрытия для коммутационной аппаратуры. «Maschinenwelt und Elektrotechnik», 1955, 10, № 17.
35. Электронное устройство для предупреждения н/сл. при работе кранов. «Dower Engineering», 1955, 59, № 7.
36. Guillon C., Сигнализатор для крана, «Cahiers come prevent batim et travail publics», 1956, 11, № 3.
37. Балуев В. К., Электрифицированный инструмент, Воениздат, 1955.
38. Jennings R. E., Защита переносного инструмента, «Electrical Review», 1956, 158, № 3
39. Mak-Donald, Зануление и заземление, «News International Association Electrical I-nspectors, 1955, 27, № 5.
40. Олехнович Н. В. и Ясный В. К., Автоматический контроль изоляции электрических установок 380 *в*, «Электричество», 1955, № 10.
41. Kervran L., Защитные заземляющие устройства, «Cahiers prevent batimet travail publics», 1958, 13, № 5.
42. Robbins I. A., Защита от утечки тока на землю. «Electrical Contractor and Retailer», 1958, I, 43639, II, 56, № 660.
43. Gilbert T. C., Значение времени отключения и сопротивления в цепи тока замыкания на землю при расчете безопасности, «Electrical Times», 1955, 128, 3336.
44. Резиновые перчатки небезопасны. «Electric. Light and Power», 1956, 34, № 9.
45. Irresberger G., Применение изоляционных колпаков, «Oster Elektrizitatswirtschaft), 1956, 9, № 3.
46. Правила устройства, электроустановок, Госэнергоиздат, 1960—1961.
47. Правила технической эксплуатации и безопасности обслуживания электроустановок промышленных предприятий, Госэнергоиздат, 1961.
48. Правила пользования и испытания защитных средств, применяемых в электротехнических установках. Сборник действующих правил по технике безопасности, Госэнергоиздат, 1955.

Часть вторая. Электрическое поле

49. Милицын В. А., Короткие и ультракороткие волны в медицине, «Курортология и физиотерапия», 1934, № 5.
50. Малов Н. Н., К вопросу о селективном нагревании тканей ультракороткими волнами, «Курортология и физиотерапия», 1934, № 1.
51. Малов Н. Н., О влиянии длины волны на время гибели животных в электрическом поле ультравысокой частоты, «Курортология и физиотерапия», 1934, № 5.

Page 522.

52. Рахманов Л. В., Шик Р. Г. и Обросов А. Н., Действие на животный организм электрического поля, «Курортология и физиотерапия», 1934, № 5.

53. Френкель Г. Л., Электрическая лихорадка, изд. Военно-морской медицинской академии, 1945.

54. Осипов Ю. А., Токи высокой частоты как профессионально-гигиенический фактор. Труды Первой Ленинградской конференции, «Промышленное применение токов высокой частоты», Машгиз, 1952.

55. Осипов Ю. А., Вопросы гигиены труда при применении токов высокой частоты. Труды юбилейной научной сессии, посвященной 30-летию деятельности Гос. института гигиены труда и профзаболеваний, 1957.

56. Вологдин В. П., История, важнейшие задачи и перспективы применения токов высокой частоты в промышленности. Труды Первой Ленинградской конференции, «Промышленное применение токов высокой частоты», Машгиз, 1952.

57. Лозинский М. Г., Генераторостроение для промышленной высокочастотной электротермии, «Электричество», 1948, № 12.

58. Мондрус Д. Б., и др., Унификация высокочастотных установок, «Электричество», 1948, № 4.

59. К статье Мондруса Д. Б. и др., Унификация высокочастотных установок (дискуссия), «Электричество», 1948, № 10.

60. Мондрус Д. Б., Высокочастотные ламповые установки для индукционного и диэлектрического нагрева, «Вестник электропромышленности», 1950, № 6.

61. Нетушил А. В. и Гольдблатт Б. А., Высокочастотная сушка и пропитка древесины, «Электричество», 1948, № 4.

62. Бабат Г. И., Лозинский М. Г., Поверхностное упрочнение стали обработкой токами высокой частоты, изд. Наркомсредмаш СССР, Центральный дом техники, 1940.

63. Вологдин В. П., Токи высокой частоты и их применение в промышленности, 1947.

64. Вологдин В. П., Об использовании токов высокой частоты, «Наука и жизнь», 1952, № 9.

65. Балашов В. А. и др., Усовершенствованная высокочастотная электротермическая установка, «Вестник электропромышленности», 1952, № 3.

66. Донской А. В., Высокочастотная электротермическая установка с ламповыми генераторами, Госэнергоиздат, 1957.

67. Шамов А., Питание нагревательных установок от машинных генераторов.

68. Китайгородский Ю. И., Коган М. Г., Модернизация ламповых генераторов, «Вестник машиностроения», 1957, № 7.

69. Мондрус Д. Б., Электротермические установки с ламповыми генераторами.

70. Королькова В. И., Руководящие указания по электробезопасности установок промышленной электротермии, Профиздат, 1956.

71. Прессман А. С., Методы защиты от действия электромагнитных полей радиочастот в производственных условиях, «Гигиена и санитария», 1958, № 1.

72. Временные санитарные правила для работы с промышленными ламповыми установками высокочастотного нагрева, № 180, 1955, Мин. здравоохранения СССР.

73. Правила по технике безопасности и промышленной санитарии при работе на высокочастотных установках для предприятий и организаций машиностроения, 1958.

Часть третья. Статическое электричество

74. Дроздов Н. Г., Статическое электричество в промышленности, Госэнергоиздат, 1949.

75. Дроздов Н. Г., Электричество трения как причина взрывов и пожаров, Госэнергоиздат, 1938.

Page 523.

76. Егоров В. Н., Образование зарядов статического электричества и способ их нейтрализации, «Электричество», 1958, № 9.
77. Beach R., Grounding Principlesand Practice Static Electricity in Industry, «Electrical Engineering», 1945, May.
78. Guillou C., Опасности статического электричества, «Review General mecanique», 1959, 43, № 125.
79. Опасность, представляемая транспортерными линиями из-за статического электричества, «Coal Mining», 1958, 35, № 7.
80. Braid P. E., Langille R. C., Armstrong A. M., Изучение явлений электростатики, «Canad Journ. Technol.», 1956, 34, № 2.
81. Прибор для снятия зарядов статического электричества, «Europa-technic», 1955, № 20.
82. Barnholdt B., Rosmussen R. E. H., Измерение сопротивления утечки и статического электричества, Archive Industrial Health, 1957, 16, № 1.
83. Coker G. T., Heiple H. R., Опасность статического электричества, «SAE Journal», 1959, 67, № 6, (электризация жидкостей — углеводородов).
84. Статическое электричество, «Travail et Securité», 1959, № 7.
85. Reuss K., Опасность от статического электричества, «Betrieb und technische Uberwach,» 1958, 3, № 6.
86. Техника безопасности в нефтяной промышленности, Гостоптехиздат, 1956, 103.
87. Шоффа Н. Ф., Безопасность труда на нефтескладах МТС и совхозах, Гостоптехиздат, 1939.
88. Киселев А. П., Электризация нефти и нефтепродуктов, Энергетический бюллетень Наркомнефти, 1945, № 2—3.
89. Повроженко В. В., Организация перевозок наливных грузов на железных дорогах, 1941. Правила безопасности при эксплуатации нефтегазоперерабатывающих заводов.
90. Правила защиты от статического электричества и вторичных проявлений молнии в производствах химической промышленности, Госхимиздат, 1958.

Часть четвертая. Атмосферное электричество

91. Тверской П. П., Атмосферное электричество, 1949.
92. Круг К. А., Основы электротехники, т. 1. Постоянный ток.
93. Араго Ф., Гром и молния, СПб, 1859.
94. Александрова Л. И., В клинике поражения молнией, «Невропатология и психиатрия», 1940, № 1—2.
95. Шендерович Л. М., Три случая поражения нервной системы молнией, «Невропатология и психиатрия», 1941, № 2.
96. Оранский В. В., О поражениях нервной системы молнией, «Советская медицина», 1941, № 5.
97. Юриков П. А. и Кузнецов А. Н., Случай поражения людей молнией через осветительную проводку, «Энергетик», 1958, № 6.
98. Юриков П. А., Защита людей от грозовых перенапряжений, проникающих в жилые дома по внутренней приводке, «Энергетик», 1955, № 10.
99. Dalziel. Ch, Исследование опасности импульсных токов, «Securitas», 1955, 40, № 2.
100. Голов Н., Теория и практика громоотводов, 1896.
101. Инструкция по грозовой защите Наркомата Обороны, 1937.
102. Стекольников И. С., Молния, изд. АН СССР, 1940.
103. Grenier M., Защита зданий от молнии. «Docum-Vous-Electr-mod», 1958, 28, № 109—110.
104. Байдек М., Борисов В., Смирнов И., Обследование грозозащитных устройств в Курской и Белгородской областях, «Пожарное дело», 1958, № 6.
105. Абасов М. А., Буяновский Л. Я., Рутштейн С. М., Электроснабжение и электрооборудование нефтеперерабатывающих заводов, Гос. издательство нефтяной и научно-технической литературы, Баку, 1959.

Page 524.

106. Ларионов В. П., Защита жилых домов и производственных сооружений, Госэнергоиздат, 1960.
107. Стекольников И. С., Комельков В. С. и др. Грозозащита промышленных сооружений и зданий, изд. АН СССР, 1951.

Часть пятая. Организация помощи при поражении электрическим током

108. Гурвич Н. Л., Фибрилляция и дефибрилляция сердца, Медгиз, 1957.
109. Туркменов М. Г., Дальнейшие исследования по первой помощи при электротравме, изд. АН Киргизской ССР, 1957.
110. Штумпф Ф., Новые возможности оживления людей, «Elektrizitatswirtschaft», 1956, 55, № 1.
111. Оживление пораженных током, Power Appar. and Systems, 1958, № 38, «Electrical Review», 1956, 158, № 1.
112. Ажибаев К. А. и Эскин В. Я., Портативный дефибриллятор с универсальным пктанием, изд. АН Киргизской ССР, 1960.
113. Положение о расследовании и учете несчастных случаев, связанных с производством (утв. Постановлением Президиума ВЦСПС от 4 сентября 1959 г.), Профиздат, 1959.

ELECTRICAL SAFETY AT INDUSTRIAL ENTERPRISES

Vera Ivanovna Korol'kova

Table of Contents

Part One
ELECTRIC CURRENT

Chapter 1.	Industrial electrotrauma	3
Chapter 2.	Statistics and methods of analyzing electrotrauma [electrical traumatic injuries]	16
Chapter 3.	Methods of effective prevention of electrical traumatic injuries	20
Chapter 4.	Types of electrical traumatic injuries	25
1.	The effect of electric current	26
2.	Influence of the nature and frequency of current	27
3.	Magnitude of current and voltage	30
4.	Influence of the duration of exposure to current	36
5.	Path traveled by current	37
6.	Factors which determine the magnitude of current passing through the human body	38
7.	Electrical resistance and conductivity of the human body	39
8.	Individual features of the victim	49
9.	Electric burns	50
10.	Injuries of a mixed nature. Mechanical trauma	52

Chapter 5.	Conditions for the development of electrotrauma	52
1.	Contact with current-carrying parts	53
2.	Contact with structural parts of electrical installations which normally are not under voltage	60
3.	Conditions for the development of burns	61
Chapter 6.	Classification of electrical circuits and installations according to the degree of danger they present	62
1.	Classification by voltage	62
2.	Classification according to industrial environment	63
3.	Types of accommodations and the personnel that service them	65
Chapter 7.	Prophylaxis of electrotraumatic injuries and basic protective measures	66
Chapter 8.	Safety requirements for devices of electrical circuits, installations and equipment	72
1.	Electric lines	72
2.	Open transformer substations	83
3.	Closed transformer substations and distributing devices with a voltage higher than 1000 V	87
4.	Distributing devices and panels with a voltage up to 1000 V	97
5.	Electric wiring	103
6.	Illumination units	113
7.	Manual electrified instruments	126
8.	Power installations	131
9.	Electric cranes and hoists	140

Chapter 9.		Protection from the danger of transfer of voltage	143
	1.	Cases of voltage transfer	143
	2.	Protection from the danger of transfer of high voltage into a low-voltage network	144
	3.	Protection from the dangerous consequences of the transfer of voltage to the metal structural parts of electrical installations	147
	4.	Conditions for using devices for protection from the danger of voltage transfer to the metal structural parts of equipment	156
	5.	Elements of grounding devices	157
	6.	Metal structures of buildings and equipment used for grounding	169
	7.	Grounding device	170
	8.	Grounding in installations with a voltage higher than 1000 V	175
	9.	Interconnection between grounding devices of installations with a voltage up to 1000 V and higher than 1000 V	179
	10.	Examples of the calculation of grounding	179
Chapter 10.		Protective means	187
	1.	Designation of protective means	187
	2.	Equipping electrical installations with protective facilities	188
	3.	Requirements for main and supplementary protective facilities	190
	4.	Placards	201
	5.	Facilities for protection from the action of an arc, combustion products and mechanical injuries	201
	6.	Attachments for work at heights	205
	7.	Checking the status of follow-up, storage of protective devices, organization of periodic inspections and testing	207

Chapter 11.		Making measurements	216
	1.	Measuring the resistance of insulation	216
	2.	Devices for measuring the resistance of insulation	219
	3.	Automatic control of insulation	226
	4.	Measuring the resistance of grounding devices to the flow of current	227
	5.	Determining contact voltage	238
	6.	Determining potential distribution at grounds	240
	7.	Organizational and technical safety measures during tests and measurements	244
Chapter 12.		Electrical safety requirements during the operation of electrical installations	249
	1.	General requirements	249
	2.	Preparation and training of personnel	250
	3.	Introductory instruction	251
	4.	Instruction at the work site	251
	5.	Training	252
	6.	Operational servicing	256
	7.	Inspection of electrical installations	259
	8.	Operational switching	261
	9.	Repair-assembly operations	264
	10.	Organizational-technical measures for electrical safety	270
Chapter 13.		Organizational and technical measures of electrical safety during the operation and repair of the different types of electric circuits and electrical installations	288
	1.	Aerial lines	288
	2.	Cable lines	298
	3.	Open substations	306
	4.	Substations and distributing devices with a voltage higher than 1000 V	308

5. Power transformers 316
6. Accumulator installations 322
7. Panels for control, protection and secondary switching 325
8. Plant distributing devices and panels 330
9. Intraplant networks - wiring 333
10. Electrical illumination installations 336
11. Electric machines - electric motors 340
12. Safety requirements when working with manual electrical instruments and portable manual lamps 346
13. Additional safety measures when working in distributing facilities and on panels and substations 351

Part Two
ELECTRIC FIELD

Chapter 14. Industrial electrothermic devices and safety requirements 354
Chapter 15. Short and ultra-short waves in medicine and biology 355
Chapter 16. Short and ultra-short waves in radio devices and in industrial laboratories 364
Chapter 17. Short and ultra-short waves under industrial conditions 366
Chapter 18. Industrial installations for induction and dielectric heating 370
1. Method of induction heating 370
2. Method of dielectric, or capacitance, heating 374
3. Installations with machine generators 374
4. Installations with valve oscillators 375
5. Structural fulfillment of high-frequency installations 378

Chapter 19. Dangers which develop in installations for induction and dielectric heating and their prevention 381
1. Installations with machine generators 383
2. Installations with valve oscillators 384
Chapter 20. Basic safety requirements for industrial electrothermic installations 389
1. General requirements 392
2. Installations with machine generators 394
3. Installations with valve oscillators 396
4. Basic requirements for the operation of industrial electrothermic installations 397

Part Three
STATIC ELECTRICITY

Chapter 21. Dangers connected with the phenomena of static electrification 400
Chapter 22. Main sources of development of static electricity and the factors which influence electrification 406
1. Electrification of belt drives 406
2. Electrification of tapes, fabrics, and paper during unwinding from spindles 407
3. Electrification of dust 409
4. Electrification of combustible liquids under pressure in pipes and tanks 410
5. Measures for protection from static electrification of belt drives, fabrics, paper, tapes and dust 411

Chapter 23. Electrification of light petroleum products and safety measures during pouring 417
1. Characteristics of petroleum products based on degree of danger 417
2. Basic conditions for the electrification of petroleum products 419
3. Different cases of ignition of petroleum products from static electricity 419
4. Experience on the electrification of petroleum products during their movement and dispersement 422
5. Factors which influence the intensity of electrification 423
6. Characteristics of pouring operations from the point of view of the danger caused by electrification 425
7. Analysis of the phenomena of electrification of petroleum products during pouring operations 431
8. Operations of pouring into tanks and hand tanks 437
9. Conclusions 440
10. Safety measures during the pouring of light petroleum products 441

Part Four
ATMOSPHERIC ELECTRICITY

Chapter 24. Antithunderstorm protection of buildings and structures 450
1. Thunderstorm phenomena 450
2. Thunderstorm damage to ground objects and humans 453
3. The need for antithunderstorm protection 458

4. Types of thunderstorm protection (lightning rods) 460
5. Operating recommendations on the setting up of thunderstorm protection 474
6. Practical instructions on setting up of thunderstorm protection 479
7. Protection from secondary manifestations of lightning 481

Part Five

ORGANIZATION OF HELP IN THE CASE OF INJURY FROM ELECTRIC CURRENT

Chapter 25. Rendering of first aid in the case of injury from electric current 486
1. Getting free of current in installations with a voltage up to 1000 V 487
2. Getting free from current in installations with a voltage higher than 1000 V 487
3. Main compulsory rules in the rendering of artificial respiration 489
Chapter 26. Investigation and registration of electrical injuries 492
Appendix (standard materials and forms of documentation) 499
Bibliography 520

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